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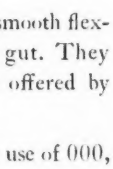

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THE EFFECT OF CHRONIC HYPERCHOLESTEROLEMIA ON SYNTHETIC AORTIC SUBSTITUTES

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IN A PREVIOUS STUDY it was observed that canine aortic homografts were more susceptible to the metabolic atherogenic factor of hyperlipemia than the recipient aorta (2). Thus, when cholesterol levels of 1,000 milligrams per cent or more were maintained, the aorta and homograft were involved alike in atheromatous lesions, whereas at lower levels of cholesterolemia the homografts alone were affected. Subsequent studies of human aortic homografts support these experimental observations, for 3 of 4 human aortic homografts examined 1 to 2½ years after transplantation revealed characteristic morphologic changes of atherosclerosis similar to lesions observed in the adjacent aorta (3). On the basis of these observations it appears that the arterial homograft is likely to develop atherosclerosis when implanted into a subject predisposed to this disease.

Increasing use of aortic prostheses made of synthetic materials naturally raises the question of susceptibility of these materials to factors producing atherosclerosis. This report is concerned with the results of some experiments to determine the effect of induced atherosclerosis on synthetic aortic substitutes.

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Supported in part by Public Health Grant No. H 1990.

METHODS

Adult mongrel dogs weighing between 10 and 15 kilograms were anesthetized with nembutal sodium given intravenously and the abdominal aorta was exposed through a midline incision. A segment of aorta 1 to 1.5 centimeters long was resected and the resulting defect bridged with an aortic prosthesis measuring 2.5 to 3 centimeters in length. The distal suture line was placed about 1 centimeter proximal to the trifurcation. About 2 weeks following operation radioiodine was administered parenterally in a dose of 1 millicurie per kilogram of body weight. The dog was then placed on a diet of horsemeat, 70 per cent, purina chow, 25 per cent, and cholesterol, 5 per cent, mixed in a tumbling type mixer. Serum cholesterol levels were determined weekly by the method

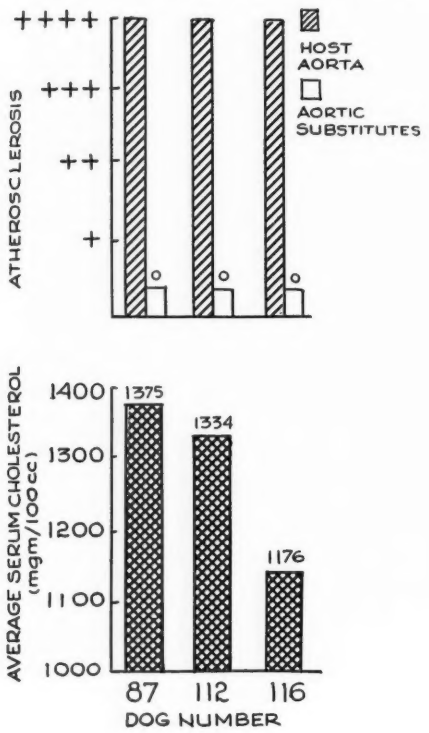

CHART 1.

described by Abell and his associates. In some instances, when serum cholesterol levels did not rise above 500 milligrams per cent, tapazole in a dose of 10 milligrams daily was added to the diet. The animals were sacrificed after varying periods of observation and the heart and aorta with the graft were removed in continuity and fixed in formalin (10 per cent) for 48 hours. The aorta was then opened longitudinally and the number and distribution of lesions in the aorta and graft were noted. Blocks of tissue were obtained for microscopic study from the graft and adjacent portions of the host aorta. Paraffin sections were prepared from each block and were stained with hemotoxylin and eosin, Masson's trichrome, and Weigert's elastic tissue stains. In addition, frozen sections were obtained from selected portions and were stained with Sudan III.

RESULTS

Of 30 animals operated upon, 13 did not survive a sufficient period of time to be included in the experiment, and 1 animal was inadvertently destroyed before necropsy could be performed. Among the 16 remaining, 9 had nylon prostheses (taffeta weave) implanted into the abdominal aorta, and in 7 the prosthesis was constructed of knitted orlon (Fig. 1). The length of time elapsing from operation to sacrifice varied between 4.75 and 14.25 months. The duration of cholesterol administration varied from 3.25 to 13.5 months; however, in only 2 animals was cholesterol administered for less than 6 months.

Average serum cholesterol levels ranged from 261 milligrams per cent to 1,375 milligrams per cent. There were 3 animals in which the average serum cholesterol exceeded 1,000 milligrams per cent (Chart 1), 8 in which the range was 600 to 1,000 milligrams per cent (Chart 2), and 5 with levels less than 600 milligrams per cent (Chart 3).

The gross and microscopic appearance of synthetic aortic substitutes following implantation has been previously described.

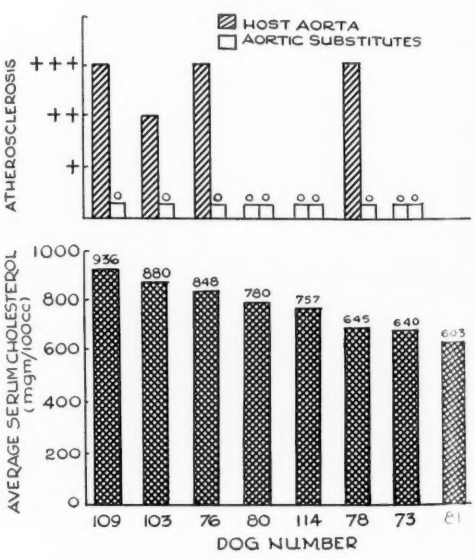

CHART 2.

After 6 months the prosthesis is completely covered by fibrous connective tissue so that the suture lines are obscured. When opened, the inner surface is covered by a smooth, glistening, transparent membrane through which the interstices of the fabric can be seen (Fig. 2). This inner lining extends past the lines of anastomosis onto the inner surface of the aorta and then blends imperceptibly into the endothelium. It is contiguous with the connective tissue layer on the outside through the interstices of the fabric. Histologically, the inner and outer coverings of the prostheses are composed of fibrous connective tissue in various stages of development (Fig. 3). At 6 months, areas of hyalinization are seen and at 1 year most of the cellular elements have disappeared. Although for the first few months after transplantation the connective tissue cells form an endothelium-like inner surface; in time the cell nuclei are lost and the inner lining becomes completely hyalinized.

Since there were no significant differences between the results with nylon and orlon prostheses, the two groups of animals are considered together. The gross and microscopic appearance and distribution of the atheromatous lesions were similar to those previously described, and the same correlation was noted between severity of atherosclerosis and degree of hypercholesterolemia. Essentially, these lesions consisted of yellow-orange plaques 0.1 to 1.0 centimeter in diameter occurring in the coronary arteries, at the orifices of intercostal arteries and throughout the abdominal aorta. Microscopically, these lesions consisted of infiltrations of foam cells and inflammatory cells into the intima, media, and around vasa vasora in the adventitia (Fig. 5). In some areas the elastic fibers were fragmented and cholesterol clefts were evident.

Nine prostheses were patent at the time of examination and 7 were occluded. In all instances of occlusion, peripheral pulses had been present for several months following operation and disappeared when the prosthesis became occluded. Of the occluded grafts there was only 1 in which constriction of the entire graft was present. There were

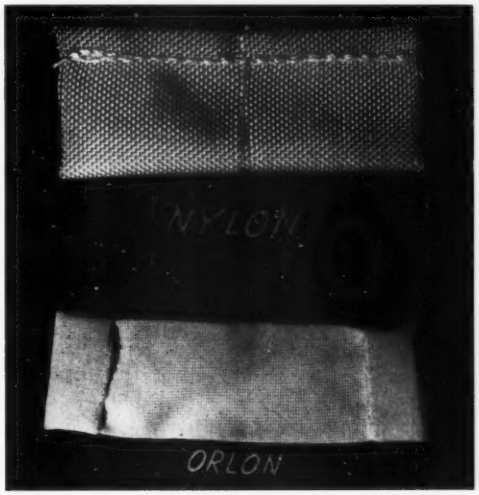

FIG. 1. Photograph of nylon and orlon prostheses used in these experiments. The nylon tube was made on the sewing machine and the orlon tube was knitted commercially. Both of these prostheses were boiled in a detergent and rinsed thoroughly prior to use.

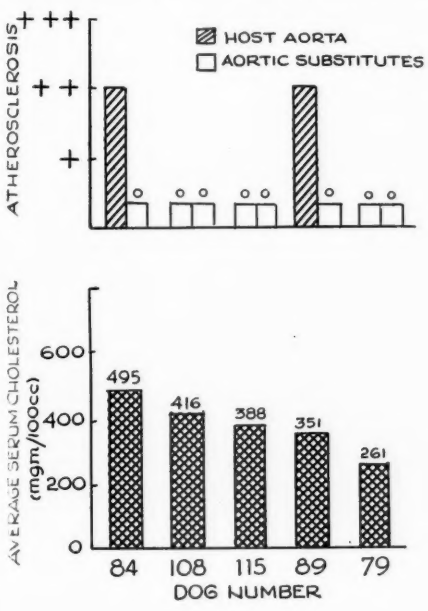

CHART 3.

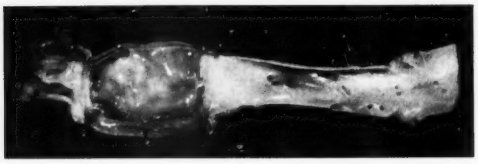

FIG. 2. The abdominal aorta and nylon prosthesis from an animal in which atherosclerosis did not develop. The aorta and the prosthesis have been opened longitudinally in order to demonstrate the smooth, glistening, transparent covering of the inner surface of the prosthesis.

FIG. 4. Abdominal aorta and orlon prosthesis 13 months after implantation and after 12 months of cholesterol. Extensive atheromatous change on inner surface of aorta, and at proximal anastomosis a large atheromatous plaque (arrow) produced occlusion of lumen. Prosthesis is patent and free from atheromatous lesions.

2 additional prostheses in which the lumen was filled with red thrombus of apparent recent development. In the 4 remaining, occlusion had occurred at the proximal suture line and the prosthesis distal to this point was patent. Significantly, there was a large atheromatous plaque at the site of the proximal occlusion in 3 specimens (Fig. 4).

Among the 16 animals comprising this study, there were 10 in which atheromatous lesions occurred in the host vessels. However, in no instance were atheromatous changes observed in the prosthesis.

DISCUSSION

The results of this study suggest that synthetic aortic substitutes made of nylon and orlon, unlike aortic homografts, do not develop atherosclerotic lesions although the adjacent aorta may be involved. Even when a severe degree of hypercholesterolemia (in excess of 1,000 mgm. per cent) was maintained for relatively long periods of time (13 months) and the natural arteries showed abundant atheroma formation, there was no evidence of atheromatous change in the prostheses. However, the occurrence of atheromas at the proximal anastomosis sufficient to occlude the lumen is particularly significant. This area represents a zone of trauma which is especially prone to lipid deposition. Similar changes at the lines of anastomosis have been observed in human aortic homografts. The plaque-to-lumen ration was great enough, however, to prevent interference with blood flow. When synthetic tubes are used in smaller vessels such as the femoral arteries in man or the abdominal aorta in dogs, development of

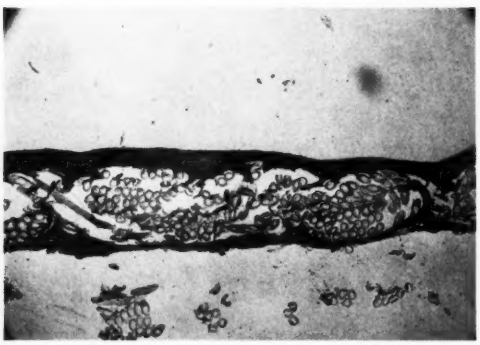

FIG. 3. Microscopic appearance of the nylon prosthesis shown in Figure 2 ten months after implantation. The nylon fibers are surrounded by fibrous connective tissue which has infiltrated the interstices to link the inner and outer coverings of the prosthesis.

FIG. 5. Microscopic appearance of the abdominal aorta of an animal in which high serum cholesterol levels were maintained for 6 months. The intima and outer portion of the media are infiltrated with foam cells with beginning disruption of some of the subadjacent elastic fibers.

atheromas at the lines of anastomosis may result in luminal occlusion.

It is doubtful that longer periods of observation would produce any significant difference in the result, since, in most instances, the connective tissue which had enveloped the prostheses was adult and the process of acceptance of this foreign material appeared to be stabilized. Synthetic aortic substitutes implanted into the abdominal aorta in humans are now being examined 1 to 2 years after transplantation, and perhaps these studies will provide additional information regarding the susceptibility of these materials to atheromatous change.

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PRIMARY TUMORS OF THE RIBS AND STERNUM

CHRIS A. PASCUZZI, M.D., DAVID C. DAHLIN, M.D., and
O. THERON CLAGETT, M.D., Rochester, Minnesota

PRIMARY TUMORS of the ribs and sternum do not occur commonly. Only about 300 cases have been reported in the medical literature. As might be expected, the types of tumors arising from the ribs and sternum are about the same as occur in bones and cartilage elsewhere in the body. However, the treatment of tumors of the ribs and sternum presents some problems unlike those encountered with similar neoplasms occurring in other sites. One hundred and forty-four primary tumors of the ribs and sternum have been diagnosed and treated at the Mayo Clinic. A study of the clinical and operative records, microscopic sections, gross specimens, and roentgenograms of this series of cases has provided a unique opportunity to learn more about the behavior and treatment of these tumors. A follow-up study of these cases has been carried out to determine the results of treatment.

PREVIOUS REPORTS

One of the first series of tumors of the ribs and sternum was reported by Paget in 1897. From the literature he collected reports of 7 tumors of the sternum and 23 tumors of ribs, and from his own experience he reported 3 tumors of ribs. Twenty-four of these 33 tumors were considered to be malignant.

In 1921 Hedblom (7) reported a review of 213 tumors of the thoracic wall, of which 167 (78 per cent) arose from ribs and 46 (22 per cent) from the sternum. Twelve years later he (8) reported 78 additional cases collected from the literature and 22 encountered at the Mayo Clinic, making a total of 313 cases. This series included 36 cases of metastatic tumor and 9 more cases in which the diagnosis was uncertain. From this study he concluded that primary tumors of the thoracic wall were relatively rare, that about 74 per cent were malignant, and that radical extirpation offered the most effective available treatment.

In 1929 Heuer (9) reported a collected series of 240 cases of tumor of the thoracic wall. Some of these tumors were metastatic. About 80 per cent arose from ribs and 20 per cent from the sternum. About 75 per cent were considered malignant. There were no adequate studies of results of operation.

In 1951 O'Neal and Ackerman reviewed 96 cases of cartilaginous tumors of the ribs and sternum. Eighty-five of these cases were obtained from the literature and 11 from their own experience. Most of the tumors were located at or near the costochondral junction, and 83 per cent occurred in ribs. The tumors in their own 11 cases were all considered to be malignant. Of 36 patients listed as having benign tumors, only 3 were living and well 5 or more years after operation. These authors advocated radical resection for cartilaginous tumors because of the high incidence of malignancy, and they stressed the importance of accurate pathologic diagnosis of these tumors.

The last large study of primary tumors of the ribs and sternum was presented by Hochberg in 1953. He collected reports of 194 cases from the literature and reported 11 cases of his own. Less than half of the tumors in his series were considered to be malignant. He advocated wide excision of the tumors even though he believed most of them were benign.

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Abridgment of thesis submitted by Dr. Pascuzzi to the Faculty of the Graduate School of the University of Minnesota in partial fulfillment of the requirements for the degree of Master of Science in Pathology.

Other series of tumors of the ribs and sternum have been reported by Harrington, Speed, Janes, Sommer and Major, Dorner and Marcy, and Harper. Rare and unusual tumors of the ribs and sternum have been reported by various authors.

MAYO CLINIC SERIES

For the years 1904 through 1954, more than 2,000 primary tumors of bone were diagnosed histologically at the Mayo Clinic. Of these, 144 (approximately 7 per cent) arose from the ribs or sternum. This series, consisting of 126 primary tumors of the ribs and 18 primary tumors of the sternum, was carefully reviewed regarding clinical history, gross and microscopic findings, roentgenologic findings, and treatment. Our classification of bone tumors is a modification of that proposed by Lichtenstein and is based on histologic appearance. We have included 3 conditions often classified with bone tumors, but probably not truly neoplastic, namely: (1) fibrous dysplasia, (2) aneurysmal bone cyst, and (3) histiocytosis x or reticuloendotheliosis.

On the basis of this pathologic classification 68.3 per cent of the tumors of ribs were malignant and 31.7 per cent benign (Table I). Only 1 sternal tumor could be classed as benign. The data on the tumors according to type are presented in the sections which follow.

TABLE I.—PATHOLOGIC CLASSIFICATION OF 126 PRIMARY TUMORS OF THE RIBS

	Cases	*Per cent of malignant tumors*	*Per cent of all tumors*
Malignant	86	100.0	68.3
Chondrosarcoma	40	46.5	31.7
Myeloma	15	17.4	11.9
Osteogenic sarcoma	13	15.1	10.4
Ewing's sarcoma	8	9.3	6.3
Reticulum cell sarcoma	5	5.8	4.0
Fibrosarcoma	1	1.2	0.8
Hodgkin's granuloma	1	1.2	0.8
Hemangioendothelioma	1	1.2	0.8
Unclassified	2	2.3	1.6
		Per cent of benign tumors	
Benign	40	100.0	31.7
Fibrous dysplasia	15	37.5	11.9
Osteochondroma	10	25.0	7.9
Fibroma	4	10.0	3.2
Histiocytosis x	4	10.0	3.2
Chondroma	3	7.5	2.4
Chondroblastoma	1	2.5	0.8
Hemangioma	1	2.5	0.8
Giant cell tumor	1	2.5	0.8
Aneurysmal bone cyst	1	2.5	0.8

MALIGNANT TUMORS OF RIBS

Chondrosarcoma. The 40 chondrosarcomas comprised 31.7 per cent of all tumors of the ribs and 46.5 per cent of the malignant tumors. Males predominated in a ratio of 2 to 1, and the ages of the patients varied from 25 to 75 years. Anterior segments of the upper 5 ribs were most often involved. One of the chondrosarcomas was secondary to an osteochondroma; the remainder were primary chondrosarcomas.

The most common symptoms were pain and the presence of a mass involving the thoracic wall. In many instances the mass had been noted for months, or even a year or more, before it began to enlarge and become painful. One patient with a tumor situated near the sixth thoracic vertebra presented symptoms and signs of spinal cord compression. Another patient with a tumor of the posterior end of the left first rib had pain, weakness, and atrophy of the left arm from involvement of the brachial plexus.

These tumors varied in diameter from 1.5 to 20 centimeters and averaged about 8 centimeters. Grossly they were lobulated, firm, and cartilaginous in appearance (Fig. 1). On cut section, areas of necrosis, hemor-

TABLE II.—SURVIVAL AFTER OPERATION FOR MALIGNANT PRIMARY TUMORS OF RIBS

Tumor	*Total patients*	*Dead of tumor*	*Living with recurrence*	*Well 5 years or more postoperatively*	*Not traced**
Chondrosarcoma	40	19	5	9	7
Radical resection	17	3		9	5
Local excision	23	16	5		2
Myeloma	15	8	5	1	1
Osteogenic sarcoma	13	11		1	1
Ewing's sarcoma	8	7	1		
Reticulum cell sarcoma	5	5			
Fibrosarcoma	1	1			
Hodgkin's granuloma	1		1		
Hemangioendothelioma	1				1
Unclassified	2	2			
Total	86	53	12	11	10

*Included are patients living and well less than 5 years postoperatively.

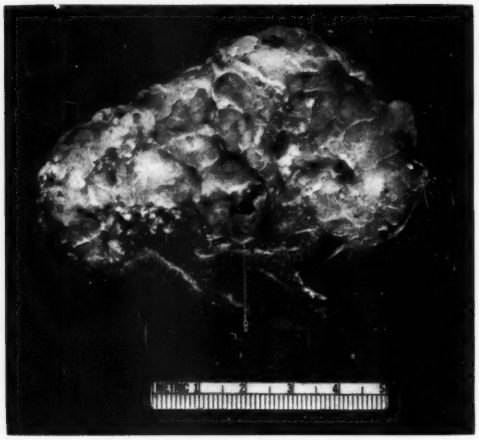


FIG. 1. Chondrosarcoma. Surgical specimen showing a lobulated, hyaline-cartilage-like tumor arising from the costochondral portion of a rib.

rhage, cyst formation, and calcification were frequently noted. Some tumors were soft and myxoid in character, others extremely hard. Twenty were classed as grade 1, 16 as grade 2, and 4 as grade 3 on the basis of their histologic characteristics (Fig. 2). Minimal evidence of malignancy included increased nuclear size, irregularity of nuclear shape, and increased numbers of multinuclear cells. These abnormalities were more pronounced in the grade 2 and grade 3 lesions.

From a review of the surgical reports and the gross specimens, it was determined that in 17 cases the operation consisted of adequate radical resection and in 23 cases it consisted of what could more properly be considered a local excision of the tumor (Table II). Of the 17 patients treated by radical resection, 3 died of recurrence of their malignant disease, 9 were well and free of recurrence for periods of 5 to 19 years, and 5 operated upon less than 5 years before this study was made were all well and free of recurrence. Of the 23 patients treated by local excision, only 5 were still living, but all had evidence of recurrence. The average length of life after local excision was 2 to 3 years. Most recurrences were noted within 1 to 2 years after operation. In 2 cases the disease recurred 5 years after operation and in 1 case it recurred 6 years after operation. Seventeen patients were treated by roentgen irradiation after operation, but there was no evidence that this treatment altered the course of the disease in any case.

Myeloma. Myeloma was the second most common malignancy encountered in the ribs. The 15 such tumors in this series constituted 17.4 per cent of malignant and 11.9 per cent of all tumors of the ribs. That the ribs are a frequent site for myeloma has been shown by Carson and co-workers, who noted involvement of them in 44 per cent of 90 cases of myeloma of bone. This study does not include cases in which the diagnosis was made by sternal aspiration. If the present series were not restricted to surgical cases, myeloma would be by far the commonest primary tumor of the ribs in the series.

Fourteen of the 15 myelomas occurred in males. The ages of the patients ranged from 28 to 63 years although most were between 40 and 60 years. All except 2 of these lesions were "solitary" when first seen. This remarkably high incidence of solitary lesions is no doubt due to the selective factors operating in a series of surgical cases of myeloma. One tumor involved 2 adjacent ribs and another showed more diffuse involvement. The most common symptom was pain, the duration of which averaged 6 months. None of these patients had Bence Jones proteinuria or other evidence of metabolic disturbance. The tumors averaged about 3 centimeters in diameter; only 3 were more than 7 centimeters in diameter. Grossly, they often extended outside the substance of the rib, forming a gray-brown, homogeneous, firm, granular mass. Areas of hemorrhage and necrosis were noted commonly. Histologically these tumors were composed of sheets of round cells slightly larger than lymphocytes; the cells had abundant eosinophilic cytoplasm and eccentric nuclei containing peripheral clumps of chromatin (Fig. 3). A few of the tumors were made up of larger

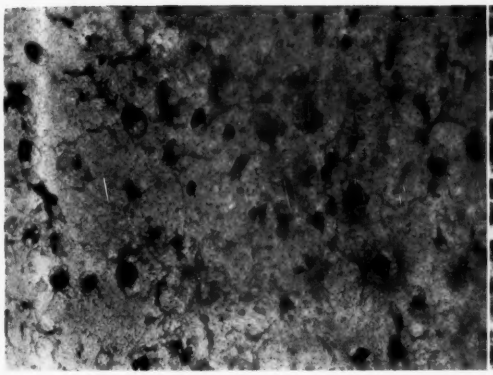


FIG. 2. Chondrosarcoma, grade 2. Many binuclear cells and cells with plump, dark nuclei are demonstrated. Hematoxylin and eosin, ×190.

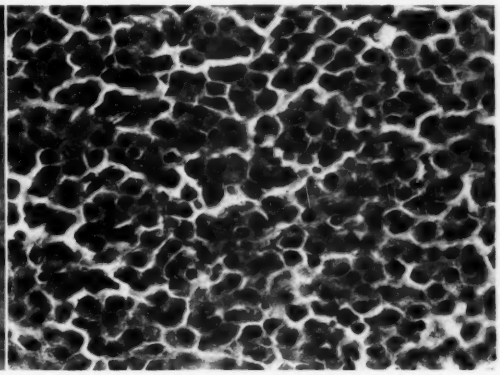


FIG. 3. Myeloma. Small cells with coarsely stippled, eccentric nuclei and rather abundant cytoplasm are shown. Hematoxylin and eosin, ×385.

more immature and pleomorphic myeloma cells. Focal deposits of amyloid were found in 2 tumors.

Radical resection was carried out in 2 cases and local excision or biopsy in 13. Roentgen therapy was employed in 6 cases. Eight patients died of disseminated myeloma within 5 years. Five patients are still living after 5 years, although they now have evidence of disseminated disease. One patient is living and well without evidence of further disease 2 years after operation, and another treated by excision and irradiation is apparently free of disease after 8 years.

Osteogenic sarcoma. The 13 cases of osteogenic sarcoma arising in ribs made up about 3 per cent of all cases of osteogenic sarcoma seen at the Mayo Clinic. Ten of the patients were males and 3 were females. The ages ranged from 13 to 53 years, with 8 patients being more than 30 years of age. The right side of the thorax was involved twice as frequently as the left. Pain was the most common symptom and had been present for an average of 5 months. The tumors were large, averaging 10 centimeters in diameter. Grossly, the lesions were fusiform or lobulated, and on cut section varied from firm, heavily calcified masses to soft, friable tumors. Areas of hemorrhage, necrosis, and cartilaginous islands were noted commonly. Histologically, these tumors consisted of a sarcomatous stroma which was composed of large anaplastic cells and in which tumor osteoid was produced by the cellular components of this stroma (Fig. 4).

Only 3 of these patients were considered to have had radical resection for their tumors. Seven of the remaining 10 were given radium or roentgen therapy after operation. One patient who was given only roentgen therapy after biopsy was living and well 20 years later. There were no other 5 year survivors, and the majority died of recurrent tumor in 1 to 2 years.

Ewing's sarcoma. The 8 patients with Ewing's sarcoma ranged in age from 6 to 59 years; half of them were less than 30. Common symptoms were pain, usually of only a few weeks' duration, and the presence of a tumor. One such tumor was symptomless, and was found incidentally on a routine thoracic roentgenogram. These tumors varied from 2 to 19 centimeters in diameter, averaging about 8 centimeters. Grossly, the tumors were homogeneous and soft, and on cut section had the appearance of lymph node tissue with multiple small areas of necrosis and hemorrhage. Cytologically, these tumors were characterized by masses of round or oval, uniform, small, closely packed cells which had little cytoplasm and uniform, round, finely chromatic nuclei (Fig. 5).

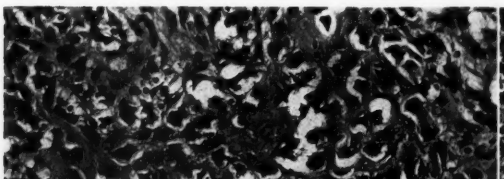


FIG. 4. Osteogenic sarcoma. Production of intercellular osteoid by sarcomatous stromal cells is shown. Hematoxylin and eosin, ×190.

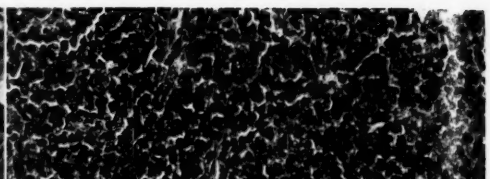


FIG. 5. Ewing's sarcoma. Uniform, small, round, closely packed cells with little cytoplasm and finely chromatic nuclei are shown. Hematoxylin and eosin, ×190.

Two patients were treated by radical resection. The remainder underwent biopsy and roentgen therapy. Seven patients were dead within 3 years, and 1 patient was living but with recurrence 1 year after operation. Most of the patients died with osseous and pulmonary metastasis.

Reticulum cell sarcoma. Of the 5 patients with reticulum cell sarcoma, 3 were males and 2 were females. Their ages ranged from 20 to 51 years. Pain was the outstanding symptom. The tumors were small, averaging less than 3 centimeters in diameter. Grossly, they resembled the myelomas of the ribs. Microscopically, the tumor cells were about twice the size of mature lymphocytes and had large oval nuclei, one or more prominent nucleoli, and scanty, faint, eosinophilic cytoplasm.

All patients were treated by local excision of the tumor and 3 were given roentgen therapy in addition. All 5 died within 3 years.

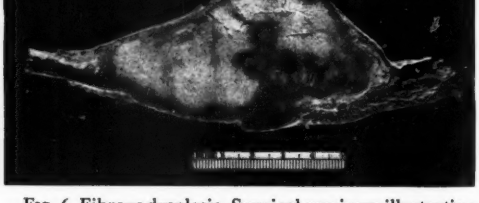


FIG. 6. Fibrous dysplasia. Surgical specimen illustrating fusiform, homogeneous, central expanding tumor of a rib.

Miscellaneous malignant tumors of the ribs included 1 Hodgkin's granuloma, 1 fibrosarcoma, 1 hemangioendothelioma, and 2 small-celled anaplastic tumors which could not be classified. The tumor diagnosed as Hodgkin's granuloma was a 6 centimeter lesion occurring in a 60 year old woman. This tumor was removed by radical resection. The patient was still alive 3 years later, but had generalized Hodgkin's disease. The fibrosarcoma occurred in a 43 year old woman. Four years after local excision and roentgen therapy this patient died of the disease. Both patients with unclassified tumors died within 18 months. The 43 year old man with hemangioendothelioma was lost to follow-up after 2 years.

The survival data for patients with malignant tumors of the ribs are summarized in Table II.

BENIGN TUMORS OF THE RIBS

Fibrous dysplasia. Fibrous dysplasia was the most common benign tumor of the ribs found in this series. It involved a single rib in 13 of the 15 cases, 2 ribs in 1 case, and 3 ribs and the ilium in 1 case. The ages of the patients ranged from 18 to 65 years, with an average age of 40 years. There was an approximately equal sex distribution. Seven

tumors were symptomless and were discovered during routine roentgenologic examination of the thorax. Some patients had pain at the site of the lesion. None had cutaneous pigmentation or signs of endocrine disturbance.

The tumors varied from 1 to 20 centimeters in greatest diameter. Grossly, each appeared as a symmetrical lesion with a central expanding mass in which the medulla was replaced by a rubbery, white, gritty tissue (Fig. 6). Usually there was a thin layer of cortical bone remaining intact over the surface. Cystic changes, areas of old hemorrhage, and calcification were commonly noted. Histologically, small irregular trabeculae of bone were scattered throughout a stroma of loose or dense fibrous connective tissue (Fig. 7). Areas of old hemorrhage and multinucleated giant cells were noted commonly.

The tumor was removed by wide resection in 8 cases and by limited local excision in 7 cases. There has been no recurrence over periods ranging up to 18 years in any of the 12 patients who could be traced.

Osteochondroma. The 10 patients with osteochondroma of the ribs in this series ranged in age from 4½ to 49 years. The lesions occurred in males twice as often as in females and were found most commonly near the costochondral junctions of the upper ribs. All were solitary tumors. Pain was rarely noted. The presence of a mass was the only sign or symptom noted in most cases. All of the lesions were small. Each arose as a stalked bony protuberance, ending in a hyaline cartilaginous cap 1 to 5 millimeters in thickness. On cut section the center of each tumor was seen to be composed of cancellous bone continuous with the marrow of the rib. A thin layer of cortical bone covered all surfaces except the distal cartilaginous cap (Fig. 8). Histologically, both bony and cartilaginous elements of these tumors were benign. All patients were treated by local excision. There were no recurrences.

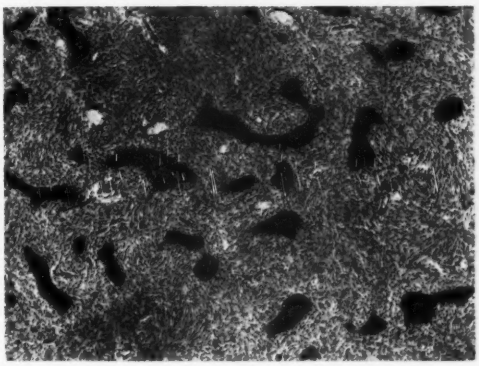


FIG. 7. Fibrous dysplasia. Small irregular trabeculae of bone in a fibrous stroma are shown. Hematoxylin and eosin, ×37.

Fibroma. The 4 nonosteogenic fibromas occurred in individuals more than 38 years of age. All were located posteriorly. Three were discovered incidentally on roentgenologic examination of the thorax. One had produced some local pain. They ranged from 1 to 5 centimeters in diameter. Grossly, the tumors were firm, homogeneous, yellow-brown masses. Microscopically, they were composed of benign fibrous tissue with scattered small foci of lipid-laden or hemosiderin-filled histiocytes. Benign multinucleated giant cells were common. All patients were treated by local excision of the tumor. There has been no recurrence.

Histiocytosis x (*reticuloendotheliosis*). The condition designated by the term "histiocytosis x" includes eosinophilic granuloma,

FIG. 8. Osteochondroma. Cross section of a surgical specimen illustrating a thin, cartilage-capped, bony stalk arising from its parent rib below.

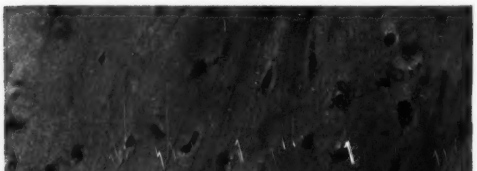


FIG. 9. Chondroma. Uniform cells with small nuclei are demonstrated. Only an occasional binuclear cell was encountered in this tumor. Hematoxylin and eosin, ×185.

Letterer-Siwe disease, and Hand-Schüller-Christian disease, which are probably all different clinical manifestations of the same disorder. Jaffe and Lichtenstein considered this group to be inflammatory in nature and not truly neoplastic. Three of the 4 patients in the present series presented solitary lesions of the ribs, without visceral involvement, and were designated eosinophilic granulomas. The fourth patient, a 1½ year old boy, had diabetes insipidus and multiple lesions of the long bones, the calvarium, and the fifth rib; therefore, his condition fell into the category of Hand-Schüller-Christian disease. These lesions were all less than 2 centimeters in diameter and resembled brown lymphoid tissue on gross examination. Microscopically, they were characterized by large masses of histiocytes sprinkled with eosinophilic leucocytes.

TABLE III.—SURVIVAL AFTER OPERATION FOR BENIGN PRIMARY TUMORS OF RIBS

Tumor	*Total patients*	*Dead of tumor*	*Living with recurrence*	*Well 5 years postoperatively*	*Not traced**
Fibrous dysplasia	15			8	7
Osteochondroma	10			6	4
Fibroma	4			3	1
Histiocytosis x	4			1	3
Chondroma	3			1	2
Chondroblastoma	1			1	
Hemangioma	1			1	
Aneurysmal bone cyst	1			1	
Giant cell tumor	1	1			
Total	40	1	0	22	17

*Included are patients living and well less than 5 years postoperatively.

Chondroma. Chondroma of the rib is rare, as evidenced by the fact that there are only 3 cases in this series. All occurred in males and in anterior segments of the ribs. Only 1 produced pain. They were 2.5 to 3.5 centimeters in diameter. Each had the gross appearance of a well circumscribed mass of adult cartilage. Microscopically, they were characterized by small uniform nuclei with only a rare binuclear cell (Fig. 9). All were treated by local excision. There has been no recurrence.

Miscellaneous benign tumors of the ribs. There was 1 case each of chondroblastoma, giant cell tumor, hemangioma, and aneurysmal bone cyst. The benign chondroblastoma occurred in a 59 year old woman. "Local excision" had been performed elsewhere twice within 18 months, but the tumor had recurred each time. Following radical resection and radiation therapy the patient has remained well for more than 15 years.

True giant cell tumor of the ribs is rare, only 10 cases having been reported. The 1 such tumor in this series occurred posteriorly in the right seventh rib of a 37 year old woman. It was treated by curettage and roentgen irradiation. The patient died 16 months later of undetermined cause.

A cavernous hemangioma of the rib that occurred in a 42 year old man was treated by local excision. It had not recurred 18 years after operation.

An aneurysmal bone cyst involved the right seventh rib of a 24 year old woman. It measured 11 by 7 by 3 centimeters and was treated by local excision. It had not recurred 8 years later.

A summary of the survival data on patients with benign tumors of the ribs is given in Table III.

TUMORS OF THE STERNUM

The 18 sternal tumors accounting for 12.5 per cent of the tumors in this series are listed in Table IV. As in the ribs, the most common neoplasm encountered was chon-

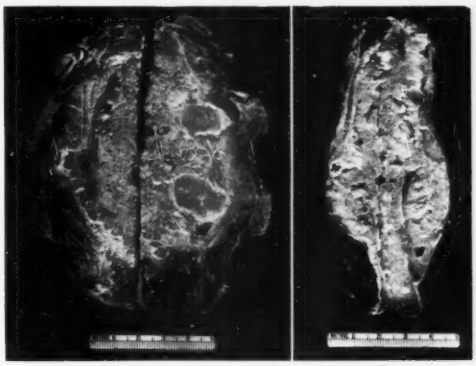
drosarcoma. Myeloma diagnosed by sternal aspiration was not included in this series. The age distribution ranged from 17 years for the patient with Ewing's sarcoma to 70 years for 1 of the patients with myeloma. The majority of the patients were in the fifth to seventh decades of life. Twelve were males and 6 were females. Tumors involved the manubrium in 9 instances, the sternal body in 8, and the ensiform process in only 1 (a case of chondrosarcoma).

The average patient with a tumor of the sternum gave a history of gradually increasing pain and swelling over a period of 3 to 4 months. If a mass had been present for a year or longer, as occurred in 7 cases, it had just recently begun to enlarge rapidly or to cause pain. The tumors varied from 2 to 10 centimeters in diameter, the average being about 5 centimeters. Figure 10 illustrates a chondrosarcoma involving the body of the sternum.

Only 2 of the 18 patients were treated by radical resection of the sternal body; since these were treated recently, they presented no opportunity for adequate follow-up studies. The remaining 16 were treated by curettage or primarily by biopsy and roentgen irradiation. Fourteen of the 18 patients received x-ray therapy either before or after operation.

Data on the 12 patients who were traced after operation are given in Table IV. Ten patients are dead of their disease after 1 to 8 years. One patient with chondrosarcoma and 1 with Hodgkin's disease are living with recurrence of the tumor after 6 years and 3 months respectively. Two chondrosarcomas and 1 osteogenic sarcoma recurred 2 or more times before causing death. All myelomas and reticulum cell sarcomas eventually became disseminated.

The single benign tumor occurred in the manubrium of a 23 year old man. This patient had no sign of recurrence 3 years after curettage of the tumor. Histologically the lesion appeared to be a benign giant cell tumor; however, because only a few small pieces were available for study, it is believed that an unequivocal diagnosis cannot be made.



a b

FIG. 10. Chondrosarcoma. a and b, Anteroposterior and lateral views of a surgically removed sternum illustrating the cartilaginous appearance of the tumor in the central portion of the gladiolus.

COMMENT

The results of this study suggest that approximately two-thirds of all primary tumors of the ribs and almost all those of the sternum must be considered malignant. The relative infrequency of benign cartilaginous tumors in the ribs and sternum is striking. On the other hand, chondrosarcoma is by far the most common tumor encountered in either location.

In reviewing the literature, particularly that prior to 1940, one is impressed by the large number of reports of chondroma, osteochondroma, and chondromyxoma of the rib cage. Typical of many case reports is 1 by Auchincloss in which he describes a

TABLE IV.—SURVIVAL AFTER OPERATION FOR PRIMARY TUMORS OF THE STERNUM

Tumor	*Total patients*	*Dead of tumor*	*Living with recurrence*	*Well 5 years postoperatively*	*Not traced**
Chondrosarcoma	7	5	1		1
Myeloma	4	3			1
Reticulum cell sarcoma	2	1			1
Osteogenic sarcoma	2	1			1
Ewing's sarcoma	1				1
Hodgkin's granuloma	1		1		
Unclassified benign	1				1
Total	18	10	2	0	6

*Included are patients living and well less than 5 years postoperatively.

football-sized osteochondroma of the left eighth and ninth ribs and a small nodule in the parenchyma of the left lung with the same histologic appearance as the benign parent tumor. The diagnosis of benign chondroma in the face of multiple recurrence such as has been reported by Heuer (10), Sommer, Hedblom (8), and others must be viewed with some skepticism. Lichtenstein has stated that he has never seen a benign central cartilaginous tumor occurring in either a rib or the sternum. O'Neal and Ackerman in their study of cartilaginous tumors of the ribs and sternum reported 11 cases of their own, in all of which the tumor was malignant.

In the present series there were twice as many males as females with primary tumors of the ribs and sternum. Almost all the myelomas occurred in males. The right side was involved in 80 cases and the left in 46 cases.

Benign tumors were quite evenly distributed throughout the entire rib cage; however, malignant tumors most frequently involved the anterior segments of the upper 5 ribs. In about 25 per cent of all cases the tumor was located either in the first or second rib. Posterior segments of the ribs were the site of tumor in about 25 per cent of the cases. Sternal tumors were about evenly divided between the manubrium and gladiolus. The ensiform process was involved in only 1 instance.

The most common symptoms were swelling and pain, varying greatly in intensity and duration. Generally, however, pain was associated more frequently with malignant than with benign tumors. Signs and symptoms of spinal cord compression due to extension of malignant lesions of the posterior segments of ribs were not uncommon. Either initially or as a terminal event malignant lesions invaded the spinal cord in 9 instances (3 cases of myeloma, 3 of chondrosarcoma, 1 of osteogenic sarcoma, 1 of reticulum cell sarcoma, and 1 of Ewing's sarcoma). None of the benign neoplasms caused this complication.

Pain, muscle weakness, or atrophy in an upper extremity secondary to compression of the brachial plexus by a tumor of the first or second rib was present in 4 cases on initial examination. One of these patients had, in addition, Horner's syndrome on the same side.

Thirteen of the 40 patients with benign tumors of the ribs were asymptomatic and the lesions were discovered by routine x-ray examination of the thorax. Only 2 malignant tumors of the ribs, a myeloma and a Ewing sarcoma, had not produced symptoms. All 18 sternal neoplasms were accompanied by pain, swelling, or both.

Trauma must be awarded an insignificant role as a possible etiologic agent, since it apparently preceded the development of symptoms in only 4 cases, and even in these there was no evidence to prove the integrity of the affected part prior to injury. Speed, Morton, and Blake and Bradford have mentioned trauma as an etiologic factor in tumors of the thoracic wall.

Although malignant tumors often recurred, only 1 benign neoplasm recurred. In this case the patient, who had a chondroblastoma, is living and well 15 years after radical resection.

In general, chondrosarcoma arising in the thoracic cage behaves not unlike chondrosarcoma elsewhere in the bony skeleton. It occurs rarely before the fourth decade and usually tends to grow slowly to a rather large size, the average diameter of those in this series being approximately 8 centimeters. If incompletely removed, it may result in pulmonary metastasis and death. The average duration of life after incomplete removal of a malignant cartilaginous tumor from the thoracic wall appears to be about 2½ years. Most recurrences take place within 2 years; only rarely is there recurrence after 5 years. In this series only 3 chondrosarcomas recurred this long after operation; 2 recurred during the fifth postoperative year, and 1 during the sixth.

It is pertinent to note that occasionally a cure may be obtained by radical removal of

a recurrent tumor. Two patients with chondrosarcoma of the ribs are living and well and are free from tumor 6 and 9 years respectively after radical resection for recurrent lesions. Irradiation therapy appeared to be of no value in the treatment of chondrosarcoma in this series.

Myeloma occurring in a single rib or in the sternum must be given a guarded prognosis; only 2 of 19 patients in the present series are living and well, without evidence of disease, after 2 and 8 years respectively. The reticulum cell sarcomas in this series behaved in much the same manner as myeloma in their pattern of dissemination to involve other osseous sites. However, it must be remembered that generally reticulum cell sarcoma of bone can be cured by either surgical or roentgen therapy in almost 50 per cent of cases. Certainly one is justified in employing judicious irradiation in the treatment of this lesion and in the treatment of apparently solitary myeloma.

As in other sites, osteogenic sarcoma involving the ribs or sternum carries a grave prognosis. Eight of the 15 patients in this series died within 2 years of operation. The single cure followed intensive roentgen therapy after biopsy of the lesion. This patient is living and well with no sign of tumor 20 years later. X-ray therapy employed as an adjunct to surgical treatment in 8 other cases did not appear to alter the course of the disease appreciably.

Ewing's sarcoma likewise has a serious prognosis. It is not surprising that there were no known survivors among the 9 cases encountered. The over-all survival rate in this disease is given as about 10 per cent.

Radical resection as has been proposed by others offers the best chance for cure in primary malignant disease of the ribs and sternum. Especially is this true of malignant cartilaginous tumors. In the present series more than half of all the patients with chondrosarcoma who underwent radical operations were free from tumor 5 to 19 years postoperatively. There was not a single 5 year cure among those who underwent local excision of the tumor. When roentgenographic examination reveals a lesion of questionable nature, one should seriously consider primary radical resection, perhaps after needle biopsy, to avoid possible soilage of the operative site with tumor cells. If incisional or aspiration biopsy is performed, care should be taken to remove the biopsy tract and the lesion intact when definitive operation is performed.

Defects in the rib cage can be covered by fascia lata grafts, pectoralis muscle, split thickness skin grafts, or periosteal flaps from adjacent ribs. In the case described by Kent and Ashburn, a metal appliance worn underneath the clothing offered ample protection. The manubrium sterni has been excised for tumor with little or no deformity resulting. Kinsella and associates have used tibial bone grafts successfully to bridge the defect.

SUMMARY AND CONCLUSIONS

The clinical records, surgical specimens, and histologic sections of 126 primary tumors of the ribs and 18 primary tumors of the sternum seen at the Mayo Clinic were analyzed. Eighty-six neoplasms of the ribs and 17 neoplasms of the sternum were malignant. On the basis of this analysis the following conclusions are suggested:

1. Chondrosarcoma is the most frequently encountered primary tumor of the ribs and sternum. With the exception of osteochondromatous exostosis, benign cartilaginous tumors of the rib cage are extremely rare.

2. Pain and swelling are the most common symptoms. The spinal cord is involved in some cases from extension of malignant tumors of posterior segments of ribs. Also, a tumor of the first or second rib may impinge on the brachial or cervical plexus and cause referred symptoms.

3. The tumors occur most commonly near the costochondral junctions of the upper 5 ribs. About 25 per cent of the tumors of the ribs in this series were found in 1 of the first 2 ribs, and about 25 per cent involved posterior segments of ribs. Ribs in the right hemi-

thorax were the site of involvement in 80 of the 126 cases.

4. Two-thirds of the rib and sternal tumors are in males.

5. Radical or en bloc resection is the treatment of choice for primary malignant neoplasms of the ribs and sternum.

6. Local recurrence of a low grade chondrosarcoma does not necessarily preclude ultimate survival of the patient.

7. Apparently solitary myeloma occurring in a rib or the sternum must be given a guarded prognosis, as is true of myeloma in other locations.

8. Asymptomatic tumors of the ribs are more likely to be benign than malignant. Recurrence is almost always a manifestation of malignancy.

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CARCINOMA OF THE INTRINSIC LARYNX

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THE PRESENT REPORT is an evaluation of several cases of carcinoma of the intrinsic larynx, with special emphasis on the clinical manifestations which influence the results of therapy. Recurrence after therapy and failure of therapy, rather than 5 year end results, were stressed. Surgical as well as irradiation failures were analyzed.

Carcinoma of the intrinsic larynx was diagnosed in 187 cases during the years 1935 through 1953. Twenty-nine of these cases were discarded from this survey for one or more of the following reasons: (1) no biopsy was made; (2) a review of the histologic slide showed a benign, rather than a malignant lesion; (3) complete or incomplete therapy was given prior to admission which made it impossible to evaluate the clinical findings before therapy; (4) treatment was refused or was taken elsewhere. A total of 158 documented cases remained for study.

SYMPTOMATOLOGY

The first symptom in every case was hoarseness. It was usually intermittent at first, but later became persistent in character. Other symptoms developed as the local disease progressed. Sore throat was a fairly common symptom. Hemoptysis occurred rarely. Dyspnea and dysphagia were late symptoms and usually were associated with either large or well advanced lesions (Table I).

Inasmuch as the hoarseness was an early and easily recognized symptom, it provided a reliable indication of the duration of the disease process. In spite of this early indicative symptom, many patients had hoarseness for several months before the diagnosis was made. Some 60 per cent of patients had received treatment from more than one physician. Several were treated unsuccessfully for "laryngitis" and the history indicated that mirror examination of the larynx was never performed.

In some instances, hoarseness was present from 2 to 5 years. The long history in these cases was usually due to papillomatosis or leucoplakia in which malignant changes eventually developed.

Cancer of the intrinsic larynx occurred most frequently in the fifth and sixth decades. The age distribution of the patients included in this survey is shown in Figure 1.

The disease occurred predominantly in males. Only 3 of the 158 cancers occurred in females.

A positive blood Wassermann was present in 5 patients but did not appear to have a clinical correlation with the disease. These patients had no clinical manifestations of lues.

The smoking history was of little significance in this small series of cases. Eighty-two per cent of the patients were smokers: 24 per cent, light smokers (10 cigarettes or 1 cigar per day); 43 per cent, moderate smokers (20 cigarettes or 3 cigars per day); and 15 per cent, heavy smokers (30 cigarettes or 5 cigars per day). Eighteen per cent of the group claimed to be nonsmokers. It has been recognized more recently that frequently a patient stated that he was a nonsmoker, but more careful questioning revealed that he had been a smoker in the past but had given up the habit. The smoking histories were taken by clerks, and it was impossible to determine if this point was adequately stressed in questioning the 18 per cent who were classed as nonsmokers.

From the Head and Neck Service A of the Roswell Park Memorial Institute, Buffalo.

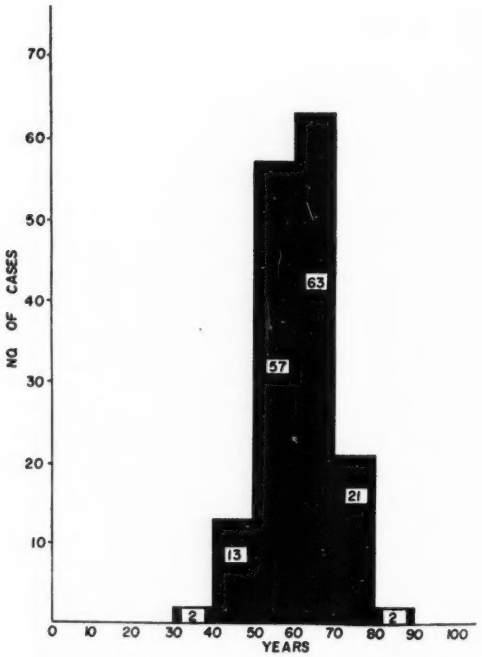

FIG. 1. Number of cases of carcinoma of the intrinsic larynx occurring in each decade.

CLINICAL EVALUATION

The evaluation of the regional disease by the Head and Neck Department was preceded by a general complete history and physical examination. The general examination included roentgenograms of the chest, electrocardiograms, hematologic studies, blood chemical determinations, and serologic studies. The regional evaluation consisted of indirect laryngoscopic examination and an evaluation of the extent of the lesion and the degree of fixation or limitation of motion of the endolaryngeal structures. The neck was carefully palpated for the presence or absence of nodes. Direct laryngoscopy was performed and the findings re-evaluated. Sampling biopsies were taken from several parts of the lesion. Recently, tomographic views of the larynx have been added to the diagnostic examination. These are particularly helpful in outlining the degree of subglottic extension.

Several clinical manifestations of the disease were considered to influence the results of therapy, both irradiation and surgical. Among these were: (1) the extent of the lesion, (2) the degree of fixation of the endolaryngeal structures, and (3) the presence or absence of metastatic nodes.

To facilitate the analysis, the cases were divided into three major categories. Category I included those lesions localized to the vocal cords, including the anterior commissure, without evidence of fixation of the cord or cords. Category II included those lesions limited to the cord or cords, including the anterior commissure, with partial or complete fixation of the vocal cord or cords. Category III included those lesions which involved the ventricular band. In the usual case, the lesion began on the cord and extended upward to involve the band. In a few instances, the lesion had its origin on the band (Fig. 2). Any lesion that involved structures beyond the anatomic limits of the band was classified as an extrinsic lesion and was not included in this study.

The initial response to surgical therapy, as compared to irradiation, was given special emphasis.

TREATMENT

Each category included cases treated initially by surgery or by irradiation. The surgery usually performed on the category I lesions consisted of laryngofissure although, in some instances, with involvement of the

TABLE I.—FREQUENCY OF SYMPTOMS IN 158 CASES OF CARCINOMA OF THE INTRINSIC LARYNX

	Hoarseness	*Sore throat*	*Cough*	*Dyspnea*	*Dysphagia*	*Hemoptysis*
Category I (Freely movable cords)	56	12	5	4	0	0
Category II (Fixed cords)	60	26	12	9	9	5
Category III (Involvement of bands)	42	15	8	12	9	1

anterior commissure total laryngectomy was performed.

In categories II and III, the operation performed most often was total laryngectomy, but in a few instances the operation consisted of laryngectomy with radical dissection of the neck.

In general, the patients treated initially by irradiation received external roentgen therapy. A few received supplemental irradiation therapy with radium pack and radon seed implantation. External irradiation has been used exclusively since 1943, and this therapy was usually administered with a 200 kilovolt modality through 2 anterolateral ports directed over the larynx, using .9 millimeter of copper (half value layer), and delivering a total tumor dose of from 4,500 to 6,000 roentgens over a 4 to 5 week period. More recently, some of the patients have been treated with the 400 kilovolt x-ray machine.

CATEGORY I

There were 56 cases in category I. By definition, these cancers were limited to the vocal cord or cords, including the anterior commissure, without evidence of fixation of the cords. The free movement of the cords indicated that, as yet, the tumor had not invaded the underlying tissues to any degree.

Only 1 of the 56 patients had palpable neck nodes at the time of treatment. This patient was treated with irradiation and died of the disease 5 months later.

Twenty-eight of these patients were initially treated with surgery and the remaining 28 were treated initially with irradiation. Figures 3 and 4 illustrate survival curves which compare the failures following surgical therapy with the failures following irradiation.

Twenty-four months following therapy, 75 per cent of the surgical group (Fig. 3) remained free of disease, 8 per cent were dead of other causes but free of disease at the time of death, 10 per cent showed evidence of recurrent disease, and 7 per cent were dead of disease.

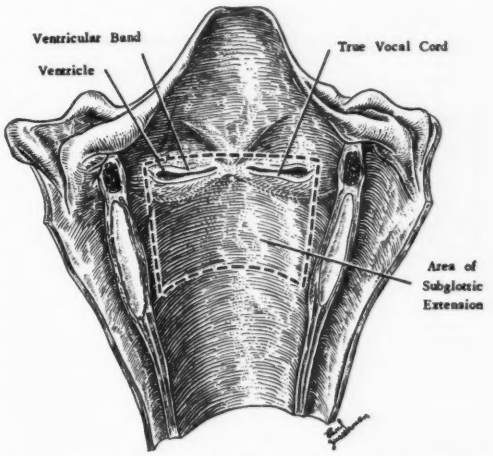

FIG. 2. Anatomic involvement in carcinoma of the intrinsic larynx. Lesions which extended beyond the dotted lines were classed as "extrinsic."

Three of the patients who developed recurrent disease following surgery were re-treated—1 by total laryngectomy, 1 by laryngectomy, with neck dissection, 1 by irradiation therapy—and all have remained free of disease. A fourth patient was given irradiation therapy but subsequently died of radionecrosis of the larynx; however, at postmortem examination there was no evidence of malignant disease.

The early lesions treated with irradiation (Fig. 4) showed a less favorable response to therapy in contrast to the group treated surgically. Initially, 75 per cent of cases responded well to x-ray therapy, whereas 25 per cent of lesions showed persistent disease during and following therapy. At the end of 24 months, only 50 per cent of these patients remained free of disease, 13 per cent were dead of other causes with no evidence of disease, 7 per cent had persistent disease, 10 per cent had developed recurrent disease, and 20 per cent were dead of disease. Two of the patients with recurrent disease were re-treated with total laryngectomy and have remained free of disease. The patients with recurrences, treated by additional irradiation therapy, all subsequently died of disease.

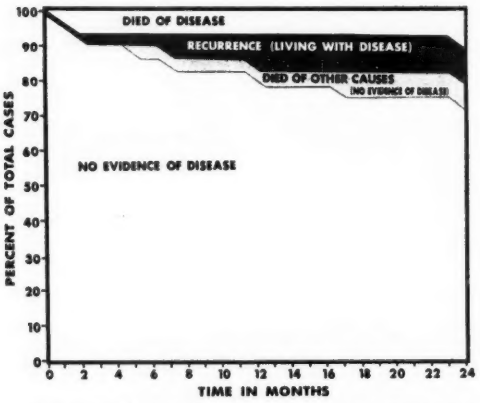

FIG. 3. Graph showing survival curves for 28 patients in category I treated by surgery.

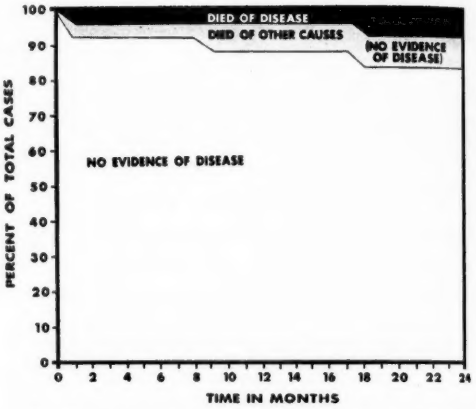

FIG 5. Graph showing survival curves for 24 patients in category II treated by surgery.

CATEGORY II

By definition, this category included those lesions limited to the vocal cord or cords, including the anterior commissure, with partial or complete fixation of the vocal cords. Vocal cord fixation was a clinical indication that the lesion now was infiltrating the deeper structures of the larynx.

There were 60 cases included in this category. Twenty-four patients were treated surgically and 36 with irradiation. The survival curves (Figs. 5 and 6) showed decidedly more favorable results in the surgical group when compared to the group treated initially by irradiation.

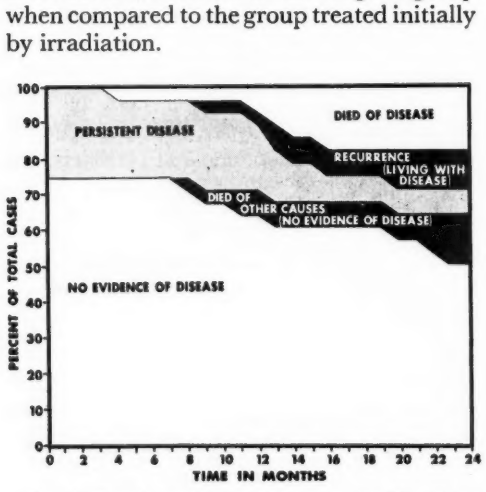

FIG. 4. Graph showing survival curves for 28 patients in category I treated by irradiation.

Twenty-four months after therapy, 83 per cent of patients treated surgically (Fig. 5) showed no evidence of recurrent disease, 9 per cent had died of other causes but were free of disease at the time of death, and 8 per cent were dead of disease.

In the irradiation group (Fig. 6), only 50 per cent of the patients showed an initial good response whereas the remaining 50 per cent showed persistent disease during and following x-ray therapy. At the end of 24 months, only 22 per cent showed no evidence of disease, 6 per cent had recurrent disease (living with disease), and 72 per cent of the patients were dead of disease. All of the patients with persistent disease following therapy were dead within 24 months.

There was some indication that in the irradiation group the lesions with partial fixation of the vocal cords responded somewhat better than those with complete fixation. Sixty per cent of the partially fixed lesions recurred or showed persistent disease whereas 94 per cent of the completely fixed lesions showed recurrent or persistent disease which again indicated that the depth of infiltration markedly influences the results of irradiation therapy.

Seven patients (12 per cent) in this category had clinically palpable nodes at the time of treatment. All 7 were treated with

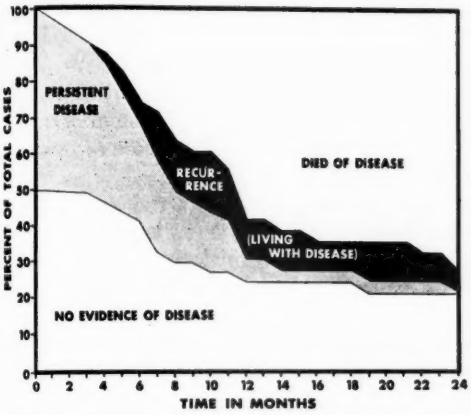

FIG. 6. Graph showing survival curves for 36 patients in category II treated by irradiation.

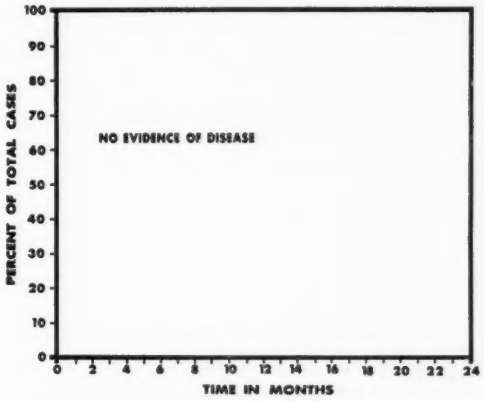

FIG. 7. Graph indicating survival of all 7 patients in category III treated by surgery.

irradiation and all 7 died of disease within 14 months of the onset of therapy.

CATEGORY III

By definition, category III included those lesions which involved the ventricular band. There were 42 cases in this category; 7 patients were treated surgically and 35 were treated with irradiation. Though the surgical group was small, the survival curves (Figs. 7 and 8) showed a marked difference.

All 7 (100 per cent) of the patients treated with surgery (Fig. 7) were alive and well at the end of 24 months.

In contrast, only 11 per cent of the irradiation group (Fig. 8) were alive and free of disease at the end of 24 months. An additional 6 per cent had recurrent disease and 83 per cent were dead of disease. Sixty-nine per cent of the patients in this group never responded to therapy and showed persistent disease until death.

It is significant to note that 7 of the band lesions showed the cords to be freely movable. These lesions began on the ventricular band (false vocal cord) proper. Four of these lesions responded favorably to irradiation therapy. These 4 cases (12 per cent of the irradiation group) account for all the patients who showed good response to irradiation therapy in this category.

Twelve patients (29 per cent) in this category had clinically palpable nodes at the time of therapy. Eleven were treated with irradiation therapy and all but 1 died of disease within 18 months' time. One was treated by laryngectomy with neck dissection and was still alive and free of disease 36 months following surgery.

IRRADIATION REACTIONS

Irradiation produced changes in the tissues which, in some degree, were considered normal following this form of therapy. All patients experienced the acute phases of the

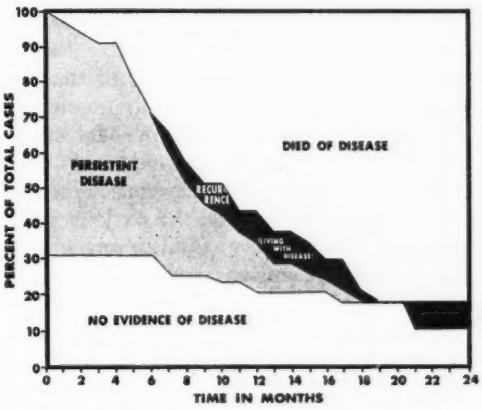

FIG. 8. Graph showing survival curves for 35 patients in category III treated by irradiation.

irradiation reaction characterized by varying degrees of mucositis, hypopharyngeal edema, and reddening and blistering of the skin. This acute reaction, as a rule, subsided in 2 to 4 weeks following therapy.

From this time on, the irradiated areas manifested late changes due to this form of therapy. A relatively high percentage of patients developed a permanent dryness of the mucous membranes. Many developed a moderate degree of chronic hypopharyngeal edema and of fibrosis of the paralaryngeal structures which as a rule was tolerated well by the patient. In some instances, however, chronic edema and thickening of tissues progressed to a degree which necessitated permanent tracheotomy and sometimes a gastrostomy.

In addition to these lesser irradiation tissue changes, 10 per cent of the patients (10 cases) treated by irradiation developed the severe complication of radionecrosis. In the usual case, this complication resulted in death. Total laryngectomy was successfully performed on 1 of these patients with radionecrosis and the patient has remained well. No surgical attempt was made to salvage the other 9 patients and all died.

CONCLUSIONS

Early lesions of the vocal cord (category I) were, in many instances, favorable lesions for laryngofissure. This type of lesion also responded well to irradiation therapy, although less favorably than similar lesions treated surgically. Involvement of the anterior commissure appeared to lessen the response of both forms of therapy. Metastases from category I lesions occurred rarely.

When the tumor caused fixation of the vocal cords (category II), the patients were best treated by surgery (total laryngectomy or laryngectomy with radical neck dissection, depending on the presence or absence of nodes). The response of these lesions to irradiation was, in most instances, unsuccessful and markedly inferior to the initial results following surgical excision. Clinical cervical metastases occurred in 12 per cent of cases in this category.

Lesions which involved the ventricular band (category III) were best treated by total laryngectomy or laryngectomy with neck dissection. Irradiation provided a good response in relatively few patients, and these were the patients with little or no fixation of the endolaryngeal structures. Clinically palpable metastatic nodes were found in 29 per cent of cases in this category.

Irradiation appeared to be most effective in the early, more superficial lesions of the intrinsic larynx. The fixed cord lesions responded poorly to irradiation in most instances. Irradiation had little, or no effect, on metastatic nodes from carcinoma of the intrinsic larynx. Severe irradiation reactions were common in patients with fixed lesions. Ten per cent of all patients treated by irradiation developed radionecrosis which, as a rule, resulted in death unless the necrotic tissues were surgically excised.

SUMMARY

1. One hundred and fifty-eight cases of carcinoma of the intrinsic larynx were reviewed.

2. The clinical manifestations of the disease which appeared to influence the response to therapy were analyzed.

3. Surgical curves comparing the initial response to surgical and irradiation therapy were presented. The material indicated that irradiation did control lesions which showed no evidence of fixation or metastatic nodes. Surgery was by far the therapy of choice for lesions with fixation or metastatic nodes.

PHANTOM LIMB IN PATIENTS WITH INJURIES TO THE SPINAL CORD AND CAUDA EQUINA

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IT IS UNFORTUNATE that the term "phantom limb" has been used to designate both the spectral sensations referred to a dismembered extremity and nociceptive and proprioceptive sensations referred to a part rendered insensible to external stimuli by disease or injury to the nervous system.

The words "phantom," or "spectral," should, we believe, be restricted to those instances of injury to the spinal cord and cauda equina in which amputation of an extremity has been performed. By some physicians, the feelings have been called hallucinations, by others illusions, whereas they are neither. Nor are they imaginations.

It has been said that a phantom limb may result from a lesion of any part of the nervous system. Bradley states it may occur "without amputation in severe lesions of the peripheral nerves with loss of sensation in the distal parts, in severe injury to the brachial plexus, or lumbo-sacral plexus, or spinal root, in transection of the spinal cord, in destruction of the posterior columns, in intramedullary lesions of the cord, brain stem and thalamus, subcortical cerebral lesions and in sensory Jacksonian epilepsy."

It is well known that pain and other sensations may be referred into areas rendered insensible in whole, or in part, in these conditions. These are not hallucinations or illusions. Quite properly Botterell and his associates state that, "the pain in paraplegics is referred to the anaesthetic area below it."

Whatever the level of the lesion may be there is a common sensation, including pain, which is referred distally. Even in so-called painless phantom limbs in amputees, Henderson and Smyth have found a mild tingling in all patients with a phantom, which they deem to be the basic phantom phenomenon. There are instances in which the patient seems to feel the position and movement of an insensible extremity. These feelings do not correspond to the actual posture or movement of the extremities. In regard to this, it must be remembered that fibers carrying nociceptive and proprioceptive impulses are involved in injury to the spinal cord. It is not strange, therefore, to find evidence of their stimulation and responses of reference of specific sensation into the periphery. Since the fibers so stimulated need not be related to actual posture or movement, one need not be surprised at the false interpretations.

In the normal patient, awareness enables the patient actually to feel posture and movement. After injury, awareness results from the recovery of sensory function, not necessarily of all modalities or of all parts.

We must confess to the errors of accepting definitions because of usage when, in a former article (7) we spoke of "phantom sensations" and of "awareness" without a clear understanding or definition of the terms.

We believe that there exist three different conditions which should be differentiated.

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Each of the many authors was concerned in time-consuming, repeated, complete neurologic examinations, the analysis of questionnaires and frequent interviews with patients.—*Editor.*

The first is the projection of a seemingly spontaneous painful or other disagreeable sensation, chiefly burning. This condition occurs in the majority of cases, waxing after injury and waning some considerable time later. The second is that of awareness of an extremity or part of it. This implies a cognizance made possible by recovery of sensation, or an injury which does not completely destroy all sensation below the level of injury. The third is the condition wherein proprioceptive sensations of posture and movement are projected into insensible extremities, or their parts. By correlating neurologic examinations, particularly of objective sensory loss with distal pain and other nociceptive sensations, with awareness and projected and distally referred sensations (so-called phantoms), we have attempted to explain these phenomena upon a neurologic basis.

MATERIAL

Two hundred and thirteen patients suffering from the residuals of injury to the spinal cord and cauda equina were studied. In all of the patients, careful neurologic examinations, including motion and sensation, were made upon a number of occasions. Questionnaires were answered by the patients at various times and personal interviews were held with each patient.

REFERENCE TO THE PERIPHERY OF PROPRIOCEPTIVE (PHANTOM) SENSATIONS AT THE MOMENT OF INJURY

If the patients had not lost consciousness, or could remember the sensations at the moment of injury, their descriptions were of interest: "As if all of the body below the neck was floating away"; "legs felt as if they were bent under me"; "as if legs were blown off"; "waves of sensations passing through whole of the body"; "as if legs were shot off"; "violent thrusting of the legs"; "as if thighs and knees flexed, although they were flat on the ground"; "seemed as if my legs were in a raised position"; "legs seemed raised up"; "my whole body felt as if being stiffened by a high voltage of electricity, this immediately was followed by a severe burning sensation in the chest and burning in the right arm."

Head has called attention to the relation of the types of spasm to the feeling of posture when observed soon after injury. He said, "select two men with gross injury to the spinal cord at the same level. Both may be unable to recognize the actual posture and movement, passive or spasmodic, of the lower extremities; and yet, if the extensor phenomena we have indicated are present the patient tends to think his legs are lying straight out in front of him, whatever their actual positions. On the other hand, the man in whom the mass reflex, flexor spasms and facilitation are well developed usually says that his legs are flexed at the knees and sometimes adds, his feet are drawn up to his hips."

In our experience, as time elapsed these phenomena diminished in numbers. Nevertheless, a sufficient number persisted and permitted a collection of descriptions: "I felt I knew where my legs were, but found it was not their true position"; "think they are lying crossed over the edge of the bed and actually are straight out in front of me"; "usual position is straight out in bed"; "I have felt that the left leg was almost out of bed, but when I looked, it was straight and in the center of the bed"; "sometimes I have a feeling that the right leg is under the left leg, but when I look it is in the center of the bed and straight out"; "usually my legs are straight out, but there have been times when I have had the sensation that my legs were crossed and seemed 2 or 3 feet apart and have found that they were perfectly straight on the bed."

"I have had various sensations concerning the position of my toes. When sensation was coming back in the right foot, I used to feel that the second toe was crossed over the top of the large toe; looking down I would see that this was not so. The other phantom sensations were in February 1946, when I used to be in bed, I would have the sensation that my toes were pointing inward, that is, my

great toe, and I would look down and see that they were pointing toward the ceiling; at other times I would have the sensation that both of them were pointing outward, again I would look down and find them pointing toward the ceiling."

"Tingling of muscles began after 2 months in the right thigh. I felt like I was moving the whole leg up at the knee, the left remained inactive." In this patient, there was recovery of sensation to the ankle on the right.

"The usual position of the thighs and legs is straight out. For a long period last year, I always felt like my upper chest and shoulders were on a table with my lower chest and body hanging over the edge of the table. Lying supine I would feel that my legs were hanging backward down to the floor while of course I was straight out in bed. But after 1 year from the time of surgery, I was able to feel or sense to some extent the position of my legs by the tilt of the pelvis. Another phantom sensation has been present for about 2 years, namely sensation of the toe on either foot sharply flexing downward and of the feet rotating inwardly, while my eyes told me that actually these members were not doing this."

"The usual position of the legs is in full extension. Sometimes the legs feel straight out but sometimes I see that they are not. Often, the feet feel dorsiflexed, when they are really plantar flexed."

Riddoch cites an interesting case, "in a man who developed a myelitis after a severe attack of herpes zoster, the residuals included among others a complete abolishment of senses of posture and passive movement and vibration in the lower extremity, including the hip. From the time of onset of his spinal symptoms, he was conscious of a phantom left lower limb."

Riddoch goes on to state, "Abolition of a spinal function below the level of a transverse lesion is unnecessary for the appearance of phantom limbs is demonstrated by cases in which the sensory loss is confined to postural and allied forms of sensation."

We would go further and say that the phantom occurs because injury to the posterior columns causes central stimulation and then centrifugal conduction follows.

In our experience, distally referred proprioceptive sensations of posture and movement are relatively rare. In this material, we found them in only 22 cases or 10.4 per cent whereas awareness was present in 120 or 56 per cent. Considering the frequency of distal burning pain, the question as to whether the fibers carrying proprioceptive sensations may degenerate more completely and rapidly must await neuropathologic study. As time elapsed after injury, the incidence of distally referred sensations of posture and movement diminished. However, the same was true of distally referred burning pain.

Of interest in respect to recovery, Bors reported a careful analysis of 50 patients with injuries to the spinal cord. Forty-three patients were supposed to have complete lesions. Soon after injury, in 21 there was dissociation between the position of the "phantom" and the actual position of the paralyzed limb. Eventually 49 felt their extremities in the position they actually were at the time of their interview. It should be obvious that unless recovery had taken place such an accurate orientation could not have been possible.

PROJECTION OF NOCICEPTIVE SENSATION

Keeping in mind the statement of Henderson and Smyth that some projected sensation, in their case a mild tingling, was the basic phantom phenomenon, it may be recalled that in a high percentage of cases of injuries to the spinal cord, a distal burning pain is present. This may occupy all of the lower extremities, or parts thereof, such as the buttock, hips, legs, or feet. When the patient feels the sensation projected into all or part of an extremity he believes he actually feels the extremity even if the extremities are dismembered.

Thirty-seven of Bors' 50 patients, all of whom had this phantom sensation, reported that this phenomenon originated from either

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one, or a combination of two or more of the following sensations, which they connected with the surface of the extremity: burning, tingling, vibration, a sensation as "though waking up," numbness, and tightness. Ten had sensations which they projected to the depth of the extremity rather than to the surface. One reported gaps, 1 "visual impressions remained," and 1 was not interrogated.

In this connection, 1 of our patients, with a traumatic lesion of the spinal cord at the level of eleventh thoracic vertebra is of interest.

He was injured on August 3, 1947 when he fell from a third story window, landing on his feet, then on the buttocks. A fracture of the twelth thoracic vertebra resulted. He suffered from a paraplegia with paralysis of bowel and bladder. Because of neurogenic arthropathy of both knees, first the right limb was amputated on June 8, 1948 and 3 weeks later the left was amputated at mid-thigh.

There was a loss of pain, touch, and cold sensations distally from the level of the eleventh thoracic on the right and first lumbar on the left. However, position sense was intact. He experienced distally referred proprioceptive sensations. When the patient had had a febrile illness before interrogation, he stated that "he felt as if both feet were extended out in a distance and that they were so long they were protruding through the wall of the hospital."

When sensibility is destroyed at any level, sensations referred into the extremities, although leading to identification of all or part of an extremity, do not lead to the patient's recognition of the actual posture, movement, or existence of the extremity.

Among 65 patients whom we studied in respect to the relation of distally referred burning pain to awareness, or actual cognizance of posture and movement, in none was there evidence of recovery. In 48 patients, there was no awareness, but burning pain was present. There were 15 patients with no burning pain or awareness; in only 1 instance was there burning pain and awareness.

Awareness, or actual cognizance of posture and movement, was present in 120 of 213 patients (56 per cent). In combined anatomically and physiologically complete lesions, it was reported by 14 of 117 patients, or 12 per cent. In physiologically incomplete lesions, it was reported in 62 of 96 patients, or 65 per cent.

The dependence of awareness upon sensory recovery is further shown by the correlation of recovery of sensation in a part of an extremity and awareness of that part only. We were fortunate in observing 10 patients in whom the area of recovering sensibility coincided with the awareness of the recovering areas. In 7 of these sensation had recovered to some degree in one lower extremity and only in that extremity was the patient aware of posture and movement of the leg and foot.

In 1 patient, there was recovery of sensation on the left side including the foot; on the right side, recovery extended only to the knee. On this side he was unable to recognize the position of the leg or foot, but on the left side recognition included the foot and leg.

In another patient, there was a return of sensation to the legs, but not to the feet. He could tell the position of the thighs and legs but not the feet. In still another patient, there was recovery of sensation to the legs but not the feet, of which he was still unaware, whereas he could feel his legs and knees.

We have shown before (6) that recovery of sensation may occur in segments not dermatomes of extremities. Recovery of sensation may also occur from above downward failing to extend into the interaxial region, thus sparing the feet, or it may recover from below upward, not extending beyond the interaxial area, thus sparing the thighs and legs. In addition, we have illustrated a case in which several actual gaps of recovery were interspersed with anesthetic ones, which would explain gaps of recognition, without recourse to psychiatric reasoning.

Further proof may be adduced from the effect of rhizotomies performed for the relief of spasms. Thus, in 1 case of a supposed

anatomically complete lesion of the fourth thoracic segment of the spinal cord, there was an awareness of the lower extremities despite the inability to demonstrate any recovery of sensation. Nevertheless, after a rhizotomy had been performed the awareness disappeared.

It is well known that conventional methods of examination for the function of various modalities of sensation are not adequate to reveal such changes as may be detected by more accurate measurement. This has been shown to be the case in lesions *only* of the posterior columns, or *only* of the anterior sensory ones. Not only are there bilateral pathways for various sensations but also pathways both in the anterior and posterior parts of the spinal cord.

In another case, sensation had returned in the perianal region, pelvis and sacral area, hip, knee, and ankle, on one side. In each of these areas the patient experienced spontaneous pain as well as awareness of the limb. After rhizotomy, all sensations disappeared as did the pain and awareness.

In another instance in which the patient had been injured in May 1944, a cordotomy was performed in 1946 for the relief of root pain without avail. In 1955, a rhizotomy was carried out from the tenth thoracic to second lumbar segment, inclusive. Prior to this, some sensation had returned. After rhizotomy there was a loss of deep sensibility on the left, not on the right, and the patient could feel where the right leg was but not the left.

That is to say, in patients in whom an adequate posterior rhizotomy had been performed for spasm also combined with anterior rhizotomy, awareness was never found. Moreover, when it had been present, in partial or recovering lesions, it disappeared following rhizotomy. When rhizotomy interrupted deep sensibility only on one side, awareness disappeared upon the adequately deafferented side and persisted on the other. When rhizotomy had preceded the amputation of an extremity, no phantom limb developed. In all patients when nociceptive sensations had been distally referred, they continued to be present even after rhizotomy. In 1 patient proprioceptive sensations had been distally referred and they continued after rhizotomy.

Awareness is nothing more than the recognition by the patient of the existence and posture of his extremities made possible by sensations, even imperfect ones, derived from the extremities. It is to be expected that this awareness is absent in all complete lesions.

It is among the patients with lesions of the cervical spinal cord that one may find the relation of the recovery of particular modalities of sensation to awareness. This is because frequently the residuals of injury in this region simulate the signs of an anterior spinal artery thrombosis with loss of pain and temperature senses and total or partial conservation of touch, vibration, joint, and pressure sense. Furthermore, more or less complete recovery of half of the spinal cord may occur.

It was at once evident that recovery of pain and temperature senses alone was not associated with awareness. The recovery of touch sensation was not always associated with awareness. Thus, touch may have recovered to some degree on both sides below the level of the lesion, but when vibration sense was absent there was no awareness. When touch, pain, and temperature sensation had recovered and vibration sense remained absent, there was no awareness. On the other hand, whenever vibration sense had recovered, awareness was present and when it remained lost, there was no awareness.

With cervical spinal cord lesions, there were but 3 instances of referred proprioceptive sensations. They appeared soon after the injury occurred and were said to have disappeared a short time afterward—in 2 patients, when sensory recovery had been noticed by the patient a few weeks subsequent to the injury. Burning pain referred to the extremities, however, was present in most patients.

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PHANTOM LIMB IN AMPUTATED EXTREMITIES OF PATIENTS WITH SPINAL CORD INJURY

The phantom of dismembered extremities lends itself to study when the amputation is combined with an injury of the spinal cord and at times additional rhizotomy, or cordotomy.

A description of illustrative cases follows:

D. D. D. was originally injured in an automobile accident on June 29, 1949. A complete physiologic interruption of function of the spinal cord at the level of the eleventh thoracic segment ensued. On October 6, 1950 a bilateral obturator section was performed in an attempt to diminish spasms. This was ineffectual and on April 24, 1951 a bilateral anterior and posterior rhizotomy from the ninth thoracic segment distally was done. Because of severe decubiti which did not recover after 6 plastic operations, he underwent a mid-thigh amputation of the right thigh on February 26, 1954 and then on June 17, 1954, in order to better balance his body weight, a mid-thigh amputation of the left side was performed. He had never been aware of his extremities, nor had he had any pain referred to them. At some time following rhizotomy, but not before, he often had the feeling that his feet were rotated externally, or turned outwardly on their side, when actually the legs were lying straight out. These feelings gradually disappeared.

In this case rhizotomy resulted in a temporary reference to the lower extremities of proprioceptive sensations. Amputations, however, produced no change in the preexisting sensations.

C. E. H. was injured by a gun shot on March 21, 1951. A complete physiologic lesion at the level of the sixth thoracic segment resulted. Because of osteomyelitis, a disarticulation of the right hip was performed on October 21, 1953 and because of pyoarthrosis of the left knee, a supracondylar amputation of the left femur was done on April 9, 1954. At times he felt as if both lower extremities were asleep or numb. He also had a sensation tingling from the hips down to the toes on both sides. He also had almost continuous burning pain in both lower extremities. The sensations remained about the same as they were before the extremities were amputated.

In this case, the development of the referred nociceptive sensations into the lower extremities were unaffected by subsequent amputation.

A. S. C. was injured on August 3, 1947 when he fell from a third story window, landing on his feet and buttocks. At the hospital to which he was taken, a fracture of the twelfth thoracic vertebra was found. Surgery revealed the dura to be intact and nothing further was done. Despite a complete flaccid paralysis of the lower extremities and complete loss of sensation below the iliac crest, he had mild extensor spasms of both legs. On June 8, 1948 a mid-thigh amputation of the right thigh was performed and this was followed by the same procedure on the left thigh 3 weeks later, both because of neurogenic arthropathy of the knee joints.

Prior to the amputation he had proprioceptive sensations referred to the toes of the right limb, seeming to be able to feel volitional movement. His sister, however, could not discern any such movement. Since his amputation, when he sits in a chair for a long time and then goes to bed lying in a supine position, he has a feeling as if his knees are bent over a pillow, the plantar surface of the feet are in contact with the pillow at the foot of the bed, and that the right foot is twisted at the ankle. In addition, he has felt as if the right big toe had been mashed.

This same patient had the unique occurrence of the sense of lengthening of the amputated extremities. Only in this case of an amputation have we observed this sensation and it has never been reported in uncomplicated injuries to the spinal cord. Moreover, in this patient extensive proprioceptive sensations referred to the extremities developed after amputation and the conclusion is that the lesion was not anatomically complete.

In one patient in whom pain and temperature senses were lost on the side of the amputation and touch and vibration sense had recovered to a considerable degree on both sides, the dismembered side seemed to be externally rotated and the patient sometimes felt as though he could move the toes. much as would occur in an amputation phantom without cord lesion.

In general, in preceding and other cases, amputation did not affect the existence of nociceptive sensations, including burning pain referred to the extremities. This also was observed to be the case when an anterior rhizotomy was performed from the first lumbar to the second sacral segment bilaterally in a patient with a spinal cord injury at the fifth thoracic segment. The burning, tingling sensation in both feet persisted in one extremity after amputation.

The reason for this result may be found in the following description of anesthetizing the distal end of the proximal segment of the spinal cord in another patient.

J. H. B. was injured on January 4, 1945 by a gun shot producing a fracture of the twelfth thoracic vertebra. A presacral neurectomy had been performed elsewhere in an attempt to relieve burning pain and crushing pain referred into the toes. This procedure was ineffectual. A cordotomy was performed on February 13, 1947 elsewhere and was without improvement. In May 1947 an amputation above the right knee was performed. Following this, the shooting, burning pain continued and was referred to both the normal and dismembered extremities. The upper level of sensory loss was at the eleventh thoracic segment. No spinal fluid could be obtained from the lumbar subarachnoid space and on March 24, 1950 spinal anesthesia above the block was performed. This resulted in a disappearance of both the nociceptive and proprioceptive distally referred sensations.

We believe that this result indicates that the sensations originate at the distal end of the cord proximal to the level of the injury. In contrast, when the distal segment was anesthetized in another patient, there was no relief from his distally referred pain. He had a physiologically complete lesion at the fifth thoracic segment, and subsequent to the injury to the spinal cord he had an amputation of the right thigh. A constant burning tingling sensation as if his foot was "going to sleep" was present not only in the normal limb but also in the dismembered one. A spinal block was demonstrated and spinal anesthesia was produced by the subarachnoid injection of dextrose and procaine into the lumbar sac. The patient had no relief from the burning sensation in his feet at any time.

DISCUSSION

It is unfortunate that the word "phantom" has been used to designate both the spectral sensations referred to a dismembered extremity and to sensations, both nociceptive and proprioceptive, referred into a part rendered insensible to external stimuli by disease or injury to the nervous system.

We believe that the words "phantom" or "spectral limb" should be restricted to those cases of injury to the spinal cord or cauda equina in which an amputation has also been performed.

By some, these feelings have been called hallucinations, by others illusions, but they are neither; nor are they imaginations. By correlating neurologic examinations, particularly of objective sensory loss, with distal pain and other nociceptive sensations, awareness, and the projection of distally referred proprioceptive sensations (so-called phantoms), we have attempted to explain these phenomena upon a neurologic basis.

We believe that three conditions exist which should be differentiated. The first is the projection of a seemingly spontaneous painful, or other disagreeable sensation, chiefly burning. This occurs in the majority of cases waxing and waning sometime after injury. The second is that of awareness of an extremity, or part of it. This implies a cognizance made possible by recovery of sensation or an injury which does not completely destroy all sensation below the level of the injury. The third is the condition in which proprioceptive sensations of posture and movement are projected into insensible extremities, or their parts.

We have described the reference to the periphery of proprioceptive (so-called phantoms) sensations at the moment of injury. In our experience, these phenomena diminished in numbers as time elapsed, but a sufficient number persisted, and we have described the experience of some of the patients.

Distally referred proprioceptive sensations of posture and movement are relatively rare; they were found in only 10.4 per cent of 213 cases studied in contrast to awareness which occurred in 56 per cent. We believe that all sensations distally referred originate from the distal end of the proximal segment of the injured spinal cord. On the other hand, the relatively few cases of referred proprioceptive sensations (phantom) may be the result of more complete wallerian degeneration of the fibers which convey proprioceptive impulses.

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When all sensibility is destroyed at whatever level, sensations referred into the extremities, although leading to identification of all or part of an extremity, do not lead to the recognition on the part of the patient of the actual posture, movement, or existence of the extremity.

In combined anatomically and physiologically complete lesions, awareness, or actual cognizance of posture and movement, was reported by 14 of 117 patients, or 12 per cent. In physiologically incomplete lesions, it was reported in 62 of 96 patients or 65 per cent.

The dependence of awareness upon sensory recovery is further shown by the correlation of recovery of sensation in a part of an extremity and awareness of that part only. We were fortunate in observing 10 patients in whom the area of recovering sensibility coincided with the awareness of the recovering area. These included such cases as sensory recovery in only a part of an extremity, leg not foot, thigh not leg, or foot, one not the other extremity; the area external to the external axial line, not the interaxial area and vice versa, and recovery in gaps. Awareness occurred only in the area in which sensory recovery had taken place.

We have also observed that, when awareness of both lower extremities was present after adequate rhizotomy, the awareness disappeared and the sensitive parts were rendered anesthestic. Furthermore, when the rhizotomy was complete on only one side, the patient was aware of only the opposite extremity.

When rhizotomy precedes an amputation, phantom limb does not develop. In all patients, when nociceptive sensations were distally referred, they continued after rhizotomy. When proprioceptive sensations had been distally referred in one patient, they continued after rhizotomy.

The recovery of pain and temperature senses alone was not associated with awareness. The recovery of touch was not always associated with awareness. Thus, touch may have recovered to some degree on both sides below the level of the lesion, but when vibration sense was absent there was no awareness. Whenever vibration sense had recovered, awareness was present and when it remained lost awareness was absent. Nociceptive sensations, including burning pain referred to the extremities, were unaffected by amputation. The burning, tingling sensation referred to the feet of both lower extremities persisted after amputation of one.

We have shown by anesthetizing the distal end of the proximal segment of the injured spinal cord, when one extremity had been amputated, that nociceptive and proprioceptive distally referred sensations in the intact and absent extremities disappeared, the proprioceptive sensations disappearing first and recovering first. Neither rhizotomy, nor anesthetizing the distal segment of the spinal cord, was effective. This observation we suggest indicates that these sensations have their origin in the distal end of the proximal segment of the injured spinal cord.

SUMMARY

1. In injuries of the spinal cord and cauda equina the term "phantom limb" should be restricted to those instances in which a limb has been amputated.

2. In injuries to the spinal cord and cauda equina, three different types of sensation should be differentiated; (a) proprioceptive sensations and movement referred into insensible areas—so-called "phantoms"; (b) referred nociceptive sensations; and (c) awareness.

3. Awareness is possible only when the lesion is incomplete or recovering.

4. Recovery of deep sensibility is related to awareness more than are other modalities of sensation.

5. When sensations are referred into insensible extremities, subsequent amputation will not result in any change. The sensation continues to be referred into the dismembered limb, as well as into the intact one.

6. Nociceptive and proprioceptive referred sensations originate in the distal end of the proximal segment of the injured cord.

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HISTOGENETIC VARIATION OF UNDIFFERENTIATED GERMINAL CELLS OF GASTRIC MUCOSA

MARY B. STARK, Ph.D., Sc.D., Saint Paul, Minnesota

THE PRESENCE of the undifferentiated germinal cells found at the bottom of the gastric crypts in the stomach has been known since 1893. At that time Bizzozero found that from the bottom to the surface of the crypt there was a gradual increase of intracytoplasmic mucin in the epithelial cells. This, coupled with mitosis seen at this level in the gastric crypt, he interpreted to mean that the cells at the bottom of the crypts are the stem cells from which the surface epithelial elements are replenished. Mitoses are frequently found also in the neck chief cells. The latter, therefore, not only are self-replacing but also are replenished by the more proximal multiplying undifferentiated germinal cells. This mucin-secreting gradient in the crypt was also noted by Ferguson in 1928 in his studies of epithelial regeneration over denuded areas of gastric mucosa. He noticed that crypt epithelium was directly derived from an outgrowth of the undifferentiated germinal cells at the defect margin. These latter cells appeared to give rise to neck chief cells by invagination, and these seemed to maturate directly into the adult chief cells of the gastric gland. Parietal cells, according to Ferguson, were also derived from the neck chief cells. Mitoses have been observed in both chief and parietal cells.

Altered gastric mucosa, especially islands of intestinal type glands, has been reported by many European pathologists: Chuma in 1923, Moskowicz in 1923, Konjetzny in 1928, Magnus in 1937, and others. This condition was first observed by Kupffer in 1883. The article by Arey and Bothe published in 1950 presents an adequate historical review of the formation of the gastric intestinal islands by metaplasia. Schindler in 1944 and 1947 was unusually aware of the regular association of chronic gastritis and intestinal metaplasia.

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METHOD OF STUDY

The developmental transitions of gastric mucosa have been compiled from consecutive studies of gastric specimens secured surgically for a variety of causes. These were photographed and promptly sampled for histopathologic analysis, then studied primarily by means of slides stained with hematoxylin and eosin.

Altered gastric mucosa occurred commonly in this series of 1,000 surgically resected stomachs. Alterations occurred adjacent to and at a distance from ulcerative or nonulcerative, benign or malignant disease of the stomach as well as in stomachs without significant grossly observed change.

The undifferentiated germinal cells at the basal crypt level in the gastric mucosa appeared to be labile in response to known and unknown irritative stimuli. They were induced to proliferate and give rise to simple and complex, normal or hyperplastic glands. Often, by metaplasia, there was replacement of the usual mucosal elements by a simple tubular intestinal type gland with and without villi, an antral type, and even Brunner-like glands. This metaplastic process appeared to be initiated in the wake of focal or diffuse atrophy-inducing gastric mucosal disease.

Figures 1 and 2 taken from the anterior and midportion of the stomach show the proliferating undifferentiated germinal cells giving rise to tubules that extend toward the muscularis mucosa. Other cells from the same source extend upward into the crypts

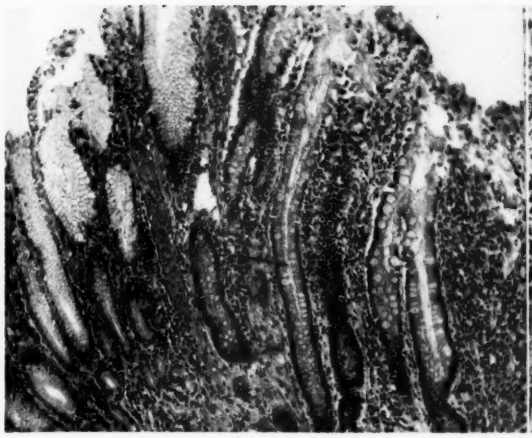
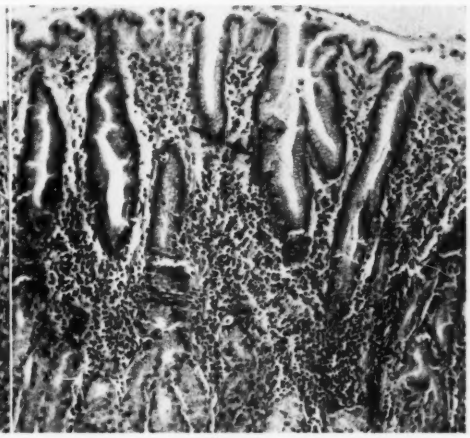


FIG. 1.



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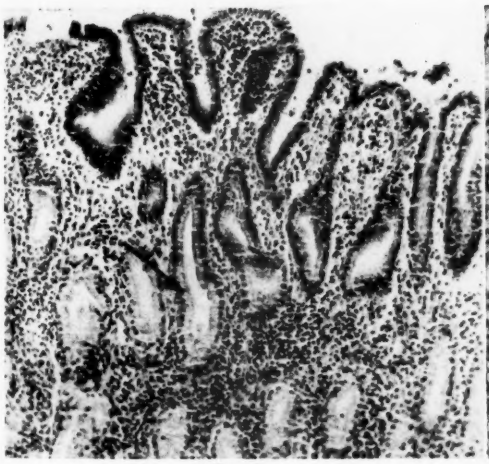

FIG. 3.

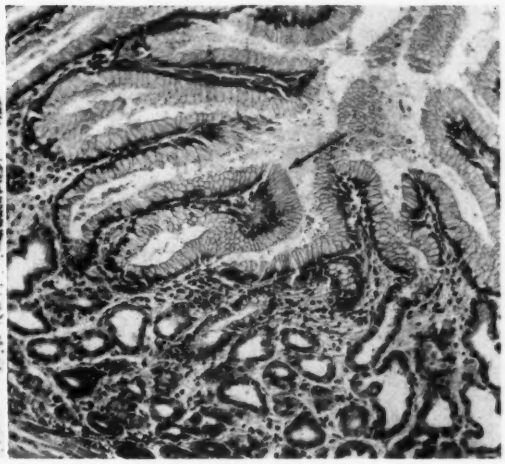

FIG. 4.

FIG. 1. Undifferentiated germinal cells (arrow) extending downward, anterior wall, midportion of stomach. ×70. Case of chronic peptic ulcer, lesser curvature, prepyloric region of stomach.

FIG. 2. Proliferating undifferentiated germinal cells (arrow) lining lower part of crypts and extending upward and downward without metaplasia, anterior wall, midportion of stomach. Case of chronic penetrating peptic ulcer in lesser curvature of antrum. Chronic diffuse atrophic gastritis.

FIG. 3. Proliferating crypts (arrow) due to the extension of undifferentiated germinal cells into same, anterior wall, midportion of stomach. ×75. Case of healing chronic peptic ulcer of juxtapylorus. Nonspecific chronic gastritis of proximal portion of stomach.

FIG. 4. Papillary hyperplasia (arrow), cystic dilatation and atrophy of gastric glands, anterior wall, midportion of stomach. ×75. Case of chronic gastric peptic ulcer, lesser curvature incisura.

and upon the gastric mucosal surface without metaplasia. In both cases, note the interstitial infiltration by lymphocytes and the loss of characteristic gastric glands, as found in chronic atrophic gastritis. Figures 3 and 4 show proliferative epithelial outgrowths of the crypt wall to form a papillary pattern of hyperplasia with tubular and cystic dilatations. The underlying gastric glands are foreshortened, atrophic, and they are replaced by tubules of undifferentiated germinal cells.

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FIG. 5.

FIG. 6.

FIG. 7.

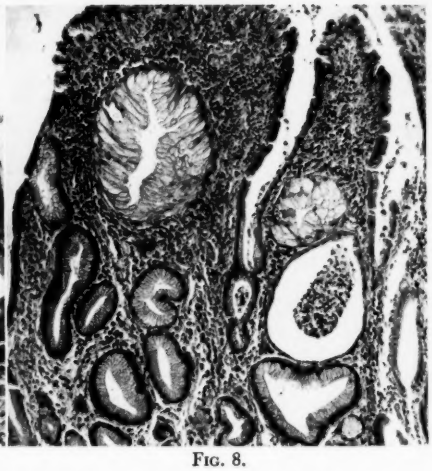

FIG. 8.

FIG. 5. Tremendous proliferation (arrow) of undifferentiated germinal cells and extension of same into surface epithelium. Adenomatous hyperplasia. ×75. Case of chronic hypertrophic gastritis.

FIG. 6. Same as Figure 5; also shows downward displacement of gastric glands.

FIG. 7. Brunner gland-like (arrow) clusters with cystic (arrow) chronic hypertrophic gastritis. ×65. A section through posterior wall, midportion of stomach.

FIG. 8. Cysts in atrophic gastritis derived from proliferating, undifferentiated cells. Glandular hyperplastic atypism. ×65. From margin of peptic ulcer I, incisura, lesser curvature.

Adenomatous hyperplasia, a profound almost neoplastic proliferation of undifferentiated germinal cells, was found in a variety of stomachs ranging from those with chronic atrophic gastritis to hypertrophic gastritis at the margins of benign ulcers or edges of carcinomas and often at great distances from these in the same stomach. In a section (Fig. 5) from a case of chronic hypertrophic gastritis, note the marked proliferation of undifferentiated germinal cells associated with papillary hyperplasia of mucin-secreting

FIG. 9.

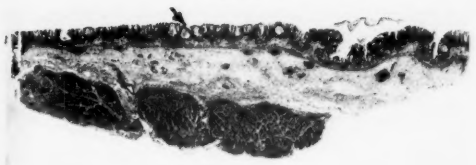

FIG. 10.

FIG. 11.

FIGS. 9, 10, and 11. Extent of adenomatous (arrow) hyperplasia, ×3.4, lesser curvature incisural level, posterior wall, and anterior wall, midportion of stomach.

crypt cells. Another section (Fig. 6) from the same stomach shows, in addition, downward displacement of gastric glands by the proliferating undifferentiated germinal cells. In a section through the posterior wall of the same stomach (Fig. 7), the mucosal cysts of hyperplastic glands and subjacent Brunner-like glands may be seen. In Figure 8, the delicate atypical fronded surface re-epithelization is demonstrated. The extensive nature of this adenomatous cystic hyperplasia and intestinal metaplasia is illustrated in Figures 9, 10, and 11 which show sections from widely separated regions of the same stomach. Figure 9 demonstrates a section from lesser curvature of incisurate portion of stomach; Figure 10, a section from posterior wall, midportion of stomach; and Figure 11, a section from anterior wall of midportion of stomach.

FIG. 12. Intestinal metaplasia with Paneth cells and villi with brush border (arrow). ×100. A case of chronic gastric peptic ulcer, lesser curvature, body of stomach, with evidence of marginal healing.

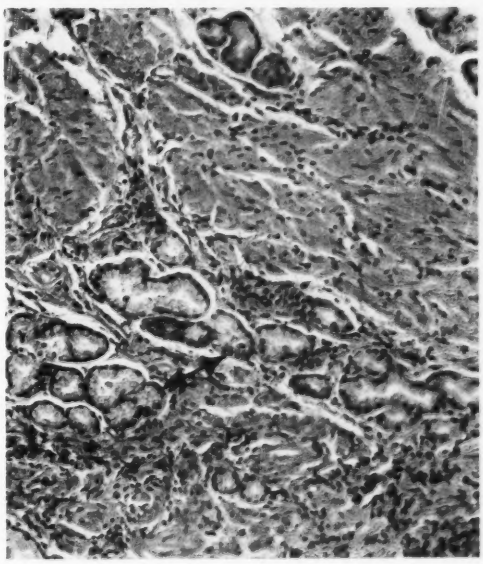

FIG. 13. Brunner gland metaplasia in anterior wall. ×100. Healed chronic peptic ulcer pyloric region of stomach.

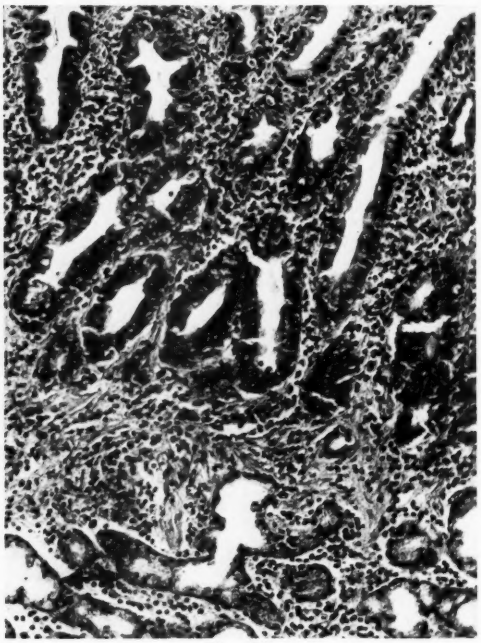

FIG. 14.

FIG. 14. Metaplasia of mucus-secreting tubuloalveolar glands (arrow) below the intestine-like glands. Severely inflamed mucosa. ×100. A case of chronic penetrating peptic ulcer of lesser curvature, juncture midportion and pylorus of stomach.

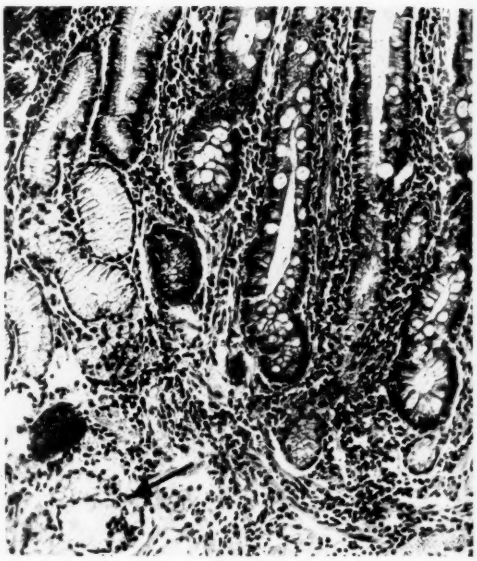

FIG. 15.

FIG. 15. Metaplasia of Brunner glands (arrow) and intestinal glands with goblet cells. To the left tubules of undifferentiated mucous neck cells. ×100. A case of benign, chronic peptic ulcer of lesser curvature of prepyloric region of stomach.

Intestinalization was often quite dramatically present (Fig. 12). Note that the villi are lined by intestine-like cells with luminally striated cytoplasmic borders, also, that the gastric mucosa is completely replaced by glands of Lieberkühn containing Paneth cells. This section is from a case of ulcerated infiltrating adenocarcinoma of the anterior wall near the greater curvature. There was a scar of healed ulcer on the lesser curvature in the antral area and an active prepyloric ulcer on the anterior wall. A section from the midportion of the anterior wall of the stomach (Fig. 13) shows Brunner gland metaplasia with glands extending through the muscularis mucosa into the submucosa. In Figures 14 and 15 note the metaplasia into hyperchromatic intestine-type glands. Beneath this change are found branching metaplastic mucus-secreting tubuloalveolar glands. To the left in Figure 15, the presence of mucus-secreting neck cell glands may be seen.

Epithelization at the site of healing ulcers and erosions closely resembles the histogenesis of gastric mucosa as found in the early stages of the human embryo. In the former, there is first found a single layer of undifferentiated epithelium derived from the marginal mucosa, migrating onto and over the surface of the ulcer or erosion and completely covering the defect as seen in Figure 16. In the latter figure, there are already invaginations from the simple undifferentiated epithelium to form primary crypts. At a later stage, further invaginations occur partially to reconstitute the mucosal glands (Fig. 17).

A section of the healed ulcer (Fig. 18) shows a series of fibropapillary, epithelized primary evaginations and invaginations. A high power view of similar evaginations

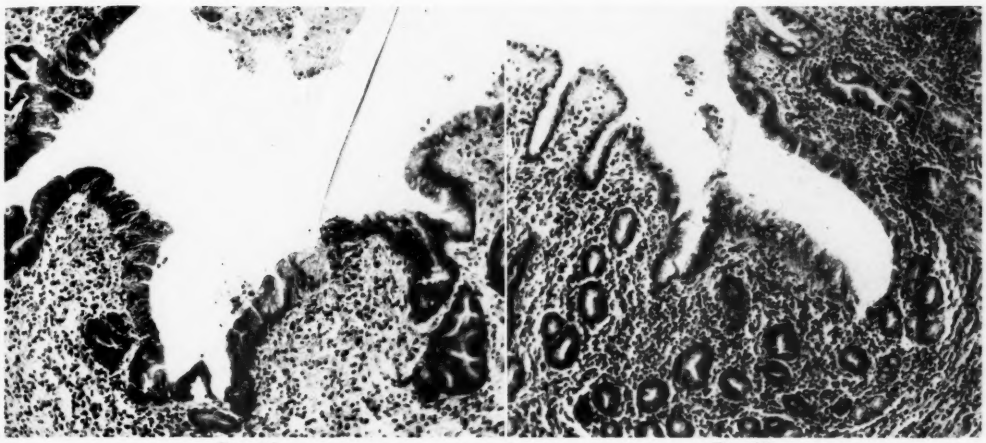

FIG. 16. FIG. 17.

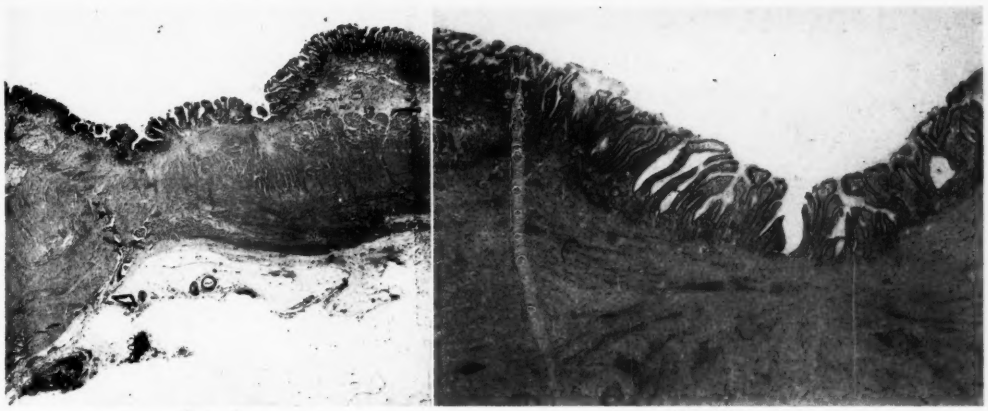

FIG. 18. FIG. 19.

FIG. 16. Healed erosion on anterior wall. ×95. A case of multiple tiny healing ulcers on lesser curvature.

FIG. 17. Healed erosion with developing gastric glands.

FIG. 18. Healed ulcer. ×13.5. A case of healed chronic peptic ulcer, lesser curvature, pylorus.

FIG. 19. Healed ulcer with epithelialized evaginations (villi) and developing glands.

from a healed ulcer from another stomach (Fig. 19) demonstrates secondary crypts lined with columnar epithelium.

Repair of gastric mucosa at the sides of ulcers and erosions never effects a reconstitution of recognizable gastric fundic glands, but rather produces variants of linear epithelial or fibropapillary patterns and abortive attempts to crypt formation. The latter includes intestinalization, tubuloalveolar (antral type) and occasionally Brunner type glandular metaplasia.

ORIGIN OF CERTAIN NEOPLASTIC PROCESSES

Undifferentiated germinal cells also play a significant role in the development of neoplastic processes, benign and malignant. At least certain neoplasms encountered bear such remarkable morphologic resemblance to undifferentiated germinal crypt cells as to warrant specific designation and definition of these forms. Figure 20 taken from a hyperplastic gastric mucosa shows a radiating hyperplasia of glands lined by undifferentiated germinal cells. Figure 21 taken from the wall

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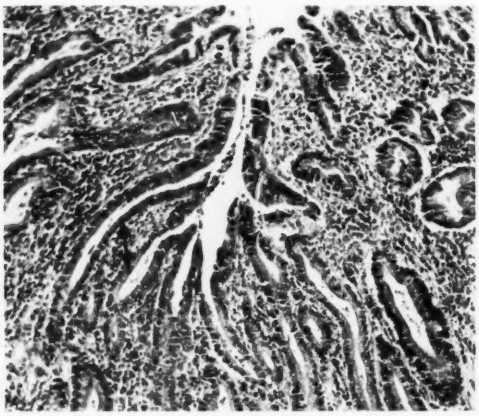

FIG. 20.

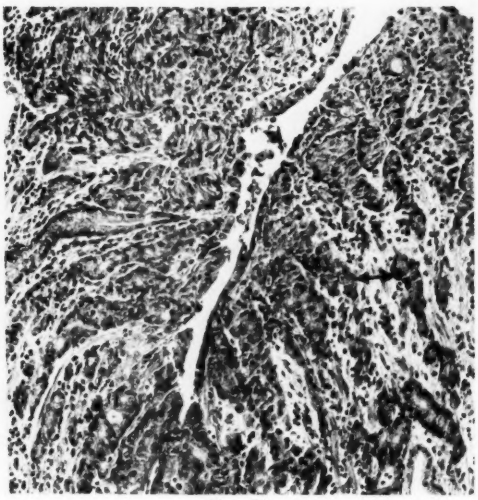

FIG. 21.

FIG. 22.

FIG. 20. Fan-shaped adenomatous hyperplasia of undifferentiated germinal cells (arrow). ×75. A case of chronic gastritis. No peptic ulcer observed.

FIG. 21. Origin (arrow) of the adenocarcinoma from the undifferentiated germinal cells. ×75. A case of adenocarcinoma of lesser curvature, proximal one-half of stomach.

FIG. 22. Origin of adenocarcinoma from the undifferentiated germinal cells (arrow). ×75. A case of adenocarcinoma of cardia with well undifferentiated features.

of a stomach with an adenocarcinoma shows remarkable morphologic resemblance to Figure 20 and demonstrates an infiltrative neoplasm consisting of undifferentiated neoplastic germinal cells. Adenocarcinomas of this morphologic pattern are not uncommonly seen. This neoplasm is illustrated too in Figure 22 from a section taken from still another stomach. In the rapidly growing malignant lesions the point of origin is very quickly lost.

A NEOPLASM AT THE MARGIN OF AN ULCER

In this entire experimental study of 1,000 excised stomachs, one wondered whether a neoplasm arose at the margin of a previously demonstrated peptic ulcer. If this should occur, it was suspected that the ori-

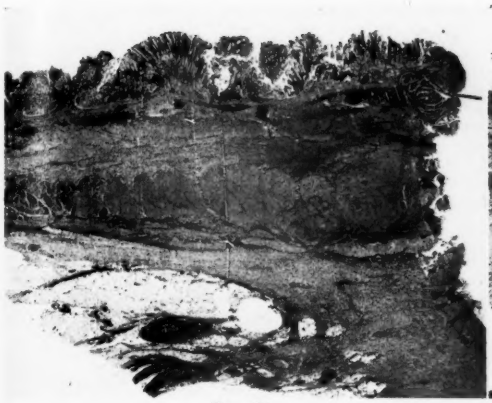

FIG. 23.

FIG. 24.

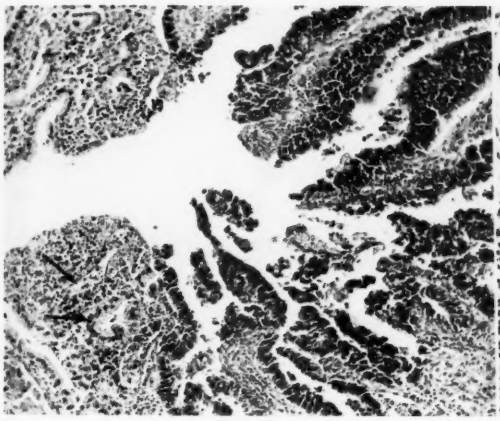

FIG. 25.

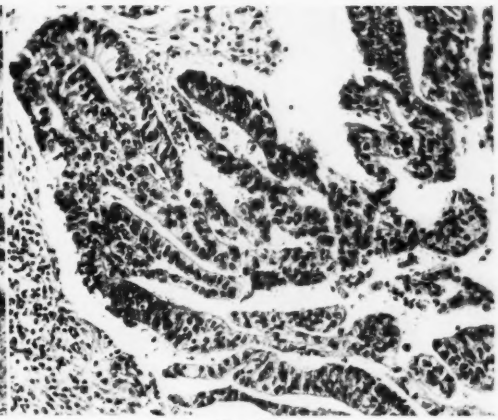

FIG. 26.

FIG. 23. Adenocarcinoma (arrow) in wedge *A* (Fig. 27) confined entirely to mucosa. ×60.
FIG. 24. Adenocarcinoma in wedge *D* (Fig. 27) extended into submucosa (arrow) ×60.
FIG. 25. High power photomicrograph of adenocarcinoma in wedge *A* (Fig. 27). Origin from undifferentiated germinal (arrow) cells.
FIG. 26. High power photomicrograph of section 150 of wedge 3 (Fig. 27).

gin of such a neoplasm would come from the abnormally stimulated undifferentiated germinal cells wandering into the ulcer base from the regenerated marginal mucosa.

Very early in the survey of excised stomachs, a stomach was found in which previous roentgenograms had shown the presence of an apparently benign peptic ulcer. This portion of the stomach was excised. The ulcer located on the incisura, lesser curvature, measured 3.0 by 2.0 centimeters in greatest diameter and 0.9 centimeter in depth (Fig. 27). The occurrence of a circularly arranged discontinuous narrow band of adenocarcinoma beneath the overhanging ulcer lip margin is clearly demonstrated in Figure 27. Photomicrographs of sections from wedges *A* and *D* (Figs. 23 and 24) show the continuity of the neoplasm with the gastric mucosa. High power photomicrographs of sections from wedges *A* and *3* (Figs. 25 and 26) show clearly the differentiation of the primitive germinal cells into the hypochromatic cells of the adenocarcinoma found at the margin of the ulcer in this case.

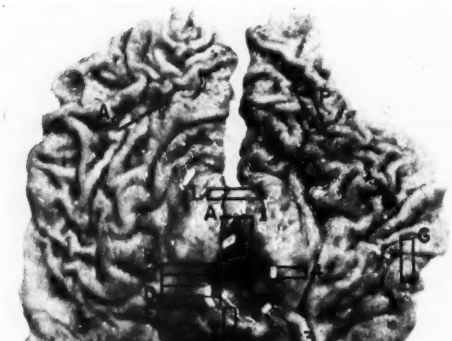

FIG. 27. Mucosal view of excised portion of stomach to show position of ulcer and its wedges removed for histologic study. Note indications of positions of adenocarcinoma at margin of ulcer in wedges *A*, *D*, *E*, *3*, and *4*.

CONCLUSION

The primitive germinal cells found at the base of the gastric crypts normally serve for ordinary replacement and regeneration. Because of their pluripotential nature, they may, by metaplasia, develop into structures that are minimally or moderately complex: intestinal type gland, antral type gland, cardiac type gland, or to the most complex—the gastric gland. Injury to the gastric glands may be followed by mucosal atrophy. Recovery and re-epithelization repair may vary from simple epithelial linear cellular arrangement with or without crypts; intestinal gland metaplasia with or without goblet cells, with or without cuticular and striated borders and Lieberkühn glands, with or without Paneth cells. The repair may induce the formation of an antral type or a Brunner type regenerative metaplasia.

Injury to the precursors of the antral or cardiac type is also followed by identical healing variants.

Injury to the primitive germinal cells may produce atypical responses. These include the development of hyperchromatic cell types, papillary patterns, cystic structures, or even adenomatous regenerative hyperplasias.

In 10 per cent of the 1,000 cases studied, there was suggestive evidence of certain forms of adenocarcinoma whose morphologic features suggest the derivation from primitive germinal cells. Neoplasms of undifferentiated germinal cells with mature orderly patterns appear to behave as though their rate of growth is slower than others of less recognizably histogenetic patterns.

SUMMARY

1. The role of the undifferentiated cell in the repair of mucosal injuries is reviewed.

2. Its typical and atypical responses are presented.

3. The role of these cells in neoplastic transformations is also presented.

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THE OPERATIVE MANAGEMENT OF SLIDING HERNIA

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"THE LITERATURE appertaining to the subject of sliding hernia may be divided into three classes, good, bad, and indifferent. The number of good articles alone is, however, so large that the ignorance which still prevails is more than surprising." So did Moschowitz introduce the subject in 1925, and today—30 years later—the statements are no less pertinent. Certainly in the last 40 years there have been several noteworthy descriptions of the development and management of sliding inguinal hernia. Additional writing on the subject would appear presumptuous and unwarranted were it not for the fact that widespread misconception still exists in the minds of many surgeons, both young and old, as to the primary objective in the management of the sac and the technical maneuvers by which this is accomplished. In some measure the confusion can be attributed to the incidence, which being low, seldom allows opportunity for concentrated individual experience. The major difficulty, however, has been the failure to emphasize in simple and clear terms the basic principles behind the management of the sac. To this end the present effort is directed.

INCIDENCE

Sliding hernias are variously reported to constitute between 1 to 4 per cent of all inguinal hernias. They are seen predominantly in men, and after the age of 40. Occasionally the lesion is seen in infants or children in which instance, of course, it is congenital. The low statistical incidence of sliding hernia is correct when the analysis includes the many types of hernias found in children and young adults. The incidence is higher, however, when only older patients are reviewed so that the surgeon performing hernioplasty on the more aged population, particularly in the presence of large hernias, finds such lesions to be common. This circumstance is well demonstrated by the statistical occurrence of cases available at the University of Cincinnati. For example, at the Cincinnati General Hospital during the years 1946 through 1955 inclusive, there have been 1,457 inguinal hernioplasties performed. Only 50 sliding hernias were encountered for an incidence of 3.4 per cent. On the other hand, at the Daniel Drake Memorial hospital, an institution for the aged and chronically ill, the percentage was much higher. Here, during the years 1952 through 1955 inclusive, 77 inguinal hernioplasties were performed, 11 of which were for sliding hernia—an incidence of 14 per cent.

CLASSIFICATION

A sliding hernia may be defined as one in which a normally intra-abdominal viscus constitutes a portion of the wall of the sac. Organs apt to be the sliding viscus in the inguinal area include the sigmoid colon, cecum, terminal ileum, bladder, fallopian tube, or ovary. Sliding hernias of the bladder are usually associated with direct hernias. They are generally handled by an operative procedure from below and will not be considered in this discussion. Moschowitz stated that the relative frequency of an organ to be involved in a sliding hernia was inversely proportional to the amount of its peritoneal covering. In this respect, therefore, as one anticipates, the cecum and ascending colon on the right and the sigmoid colon on the left are usually the offending viscera. A great deal of stress has been placed by many authors upon the classification of sliding hernias. The simplest and the most commonly agreed upon would include three varieties:

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1. The intrasaccular variety. Here, there is a pre-existing simple hernial sac into which either the sigmoid colon or cecum, for example, has prolapsed and subsequently become adherent to the hernial sac by means of adhesions. This is not a true sliding hernia.

2. The parasaccular variety. This is the type generally referred to by the term sliding hernia. In this case, the serosal surface of the bowel forms at least in part the posterior peritoneal surface of the sac.

3. The extrasaccular variety. In this instance the bowel which is extraperitoneal slides into a hernial defect of the inguinal area unaccompanied by any peritoneal projection. It is extremely rare. Development of such a hernia without a coexistent sac demands that the involved organ be completely retroperitoneal in position without any attachment anteriorly to the posterior peritoneum. In other words, it must be devoid throughout its entire circumference of a serosal layer. The statistical probability for this congenital situation to exist in the case of the cecum, sigmoid colon, terminal ileum, and so forth, is obviously infinitely small. There must be a question whether such cases cited in the literature represent the failure of the operator truly to appreciate the anatomy of the hernia and to recognize the position of the sac. This mistake we have witnessed before.

PATHOGENESIS

Classification, though desirable, is much less important than the proper understanding of the mechanics of the "slide." In the development of a sliding hernia, not one, but several factors contribute to permit the migration of the involved organ beyond the abdominal confines. These are: (1) the anatomic position of the viscus relative to the hernial orifice; (2) the size of the hernial orifice; and (3) the degree of fixation of the organ to the posterior peritoneum.

Anatomically, there are several portions of the small and large bowel which are intimately attached to the posterior abdominal wall. These are: the duodenum; the short, relatively fixed portion of the terminal ileum (usually the last 3 to 6 inches preceding entrance into the right colon); the ascending colon; the descending colon; and the iliac portion of the sigmoid colon. The intimacy of the attachment is manifestly related in each instance with the absence of a mesentery. In fact, in the case of the duodenum, the ascending colon, and the descending colon there may be no serosal covering for the posterior surfaces of such viscera. The same may be true of the iliac portion of the sigmoid colon. The cecum is the blind portion of the right colon inferior to the ileocolic junction. It is ordinarily invested on all aspects by serosa and thus lies mobile from the posterior abdominal wall superiorly to the point at which fixation of the ascending colon occurs. In 6 to 7 per cent of anatomic specimens, however, the cecum is not covered by peritoneum on the posterior aspect, and over a greater or lesser area is bound to the posterior abdominal wall by fibroareolar tissue. The knowledge of these ordinary posterior wall attachments clarifies greatly the ensuing explanations.

When a simple hernial sac progressively enlarges, as it is apt to in a long-standing hernia, peritoneal contributions must be made from both the anterior and the posterior peritoneal surfaces. As taxis and traction are exerted on the inferiorly advancing sac, portions of both the anterior and posterior parietal peritoneal surfaces pass down through the hernial ring. Anteriorly this contribution is simply made, since there are no organs with the exception of the bladder, which are adherent to the anterior peritoneal membrane. Posteriorly a different situation exists, and since the posterior peritoneum in the proximity of the hernial ring may be in fact the serosa of the cecum, the serosa of the ascending colon, the serosa of the sigmoid, or provide the short mesenteric attachment for the relatively fixed portion of the terminal ileum, such organs may slide inferiorly with the downward progress of the posterior peritoneum. When such organs are in juxtaposition to the hernial opening, the

potentialities for descent into the hernia are great, and if the hernial orifice is large, the slide proceeds without impediment. This very simple explanation satisfies all of the situations which one may encounter. Obviously, in the case of a woman, if by anatomic circumstance the fixation of the ovary and fallopian tube to the posterior peritoneal surface is in close proximity to the orifice of a hernia which is enlarging inferiorly, eventually the peritoneum fixing the organ will slide into the hernia, taking with it the adherent viscus. Occasionally, a sliding hernia will occur congenitally. This occurrence is likewise easily explained. Congenital sliding hernias predominate on the right. Embryologically when the counterclockwise rotation of the colon occurs, there is overrotation of the cecum and ascending colon into the patent processus vaginalis. Subsequently, when the mesentery of the right colon fuses with the posterior peritoneal wall, the cecum, or ascending colon, or terminal ileum may find itself lying retroserous to the processus vaginalis which never obliterates. Graham evolved an explanation for the development of sliding hernia whereby the two layers of the sigmoid colon mesentery, for example, were unfurled to produce an organ which was partially retroserous. Such an explanation, in our opinion, is unnecessary. As we see it, the anatomic disposition for partially retroperitoneal organs is already available in case of viscera normally involved in a "slide."

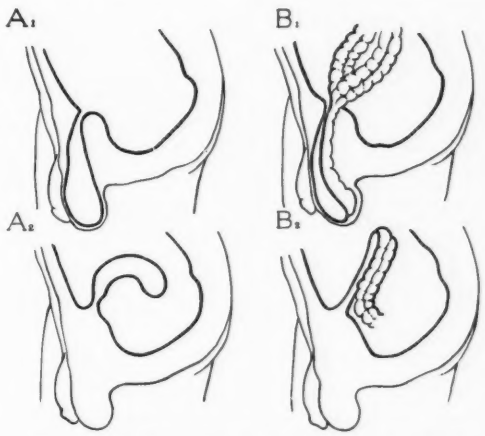

FIG. 1. This diagrammatic illustration depicts the important principle of inversion of the sac. The inversion is shown both for the simple hernia and a sliding hernia. Notice, in the case of the latter, that the anterior peritoneal wall of the sac will contribute the anterior layer of a mesentery when the bowel is directed superiorly within the abdomen.

OPERATIVE CONSIDERATIONS

The operative repair of sliding hernia has been the subject of controversy. Proponents of repair from below oppose the supporters of a combined approach utilizing the inguinal and intra-abdominal routes. The advocates of the procedure from below are chiefly Bevan, Zimmerman and Laufman, Burton and Blotner, and numerous others. Little purpose would be served by going into the intimate details of the many modifications for herniоplasty from below. In general, such procedures may be adequate for the minimal varieties of sliding hernia in which perhaps the cecum alone or a tip of the sigmoid colon has descended into the sac. However, when one discovers a bona fide sliding hernia in which the cecum and ileocolic junction, or a 6 to 12 inch loop of sigmoid colon is incorporated in the posterior wall of the sac, maneuvers from below are not easily applicable or successful. As others have pointed out, the fundamental objections to management from below under such circumstances are as follows: (1) The peritoneal sac cannot be eliminated. (2) Its high ligation is impossible. (3) If an attempt is made to eliminate the sac from below and if reperitonealization of the posterior aspect of the cecum is attempted as in Bevan's method, the following complications may ensue: (a) One may devitalize the bowel by angulation and obstruction of its circulation. (b) Similarly, angulation and torsion of the bowel may occur with mechanical obstruction of its lumen. (c) Attempts to ligate the sac by purse-string suture may cause injury to the vessels supplying the bowel with subsequent hemorrhage and may even penetrate the bowel wall giving rise to the hazards of peritonitis and fistula formation.

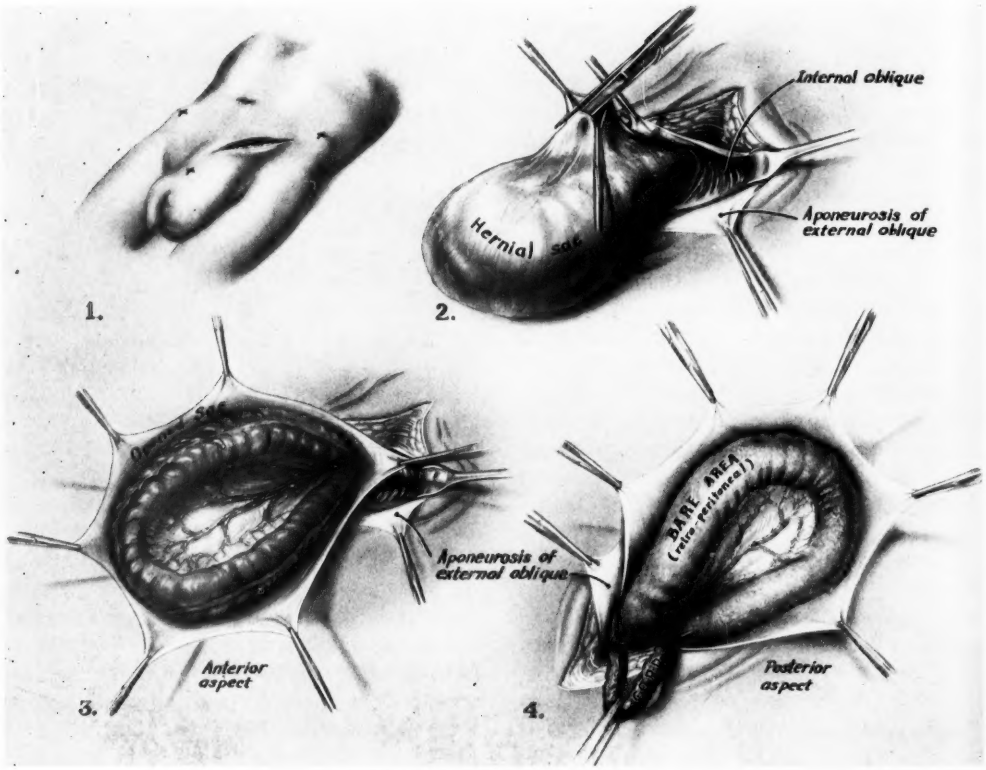

FIG. 2. Step 1, The usual hernioplasty incision. Step 2, For illustration the entire hernial sac has been freed from adjacent tissue. The sac is being opened anteriorly. Step 3, With the anterior wall of the sac open a sliding hernia of the sigmoid is visualized. The peritoneum of the posterior wall is the serosa of the sigmoid loop. Step 4, Posteriorly the sigmoid colon is bare and free of peritoneal covering.

Successful management of a sliding hernia in regard to the sac demands two fundamental accomplishments: (1) the misplaced organ must be restored within the abdominal confines; and (2) the hernial sac must be eliminated. The first objective can be accomplished from below but is not usually permanent because the second requirement is not attained. To leave a funnel projection of peritoneum invites recurrent herniation. It is the elimination of the sac, therefore, which is the crucial problem, and if this cardinal requisite of all satisfactory hernioplasty cannot be effected, permanent cure is tenuous. In simple inguinal hernioplasty the elimination of the sac is readily secured by excision and high ligation In the presence of a sliding organ, this operative solution is surgically impossible. The posterior peritoneal wall of the sac is the anterior serosal covering of a viscus and cannot be separated from the bowel successfully or without great danger. By what manner, then, can the sac be eliminated? By inversion! By turning the sac inside out! (Fig. 1). With this maneuver the peritoneal sac is not excised. Instead, the direction of the sac is reversed into the abdomen and the anterior peritoneal wall of the sac is utilized to provide a new mesenteric leaf for what previously was an amesenteric organ in a retroserous position. In this fashion the viscus can be replaced within the abdomen and the sac eliminated. Most important, the presence of any residual perito-

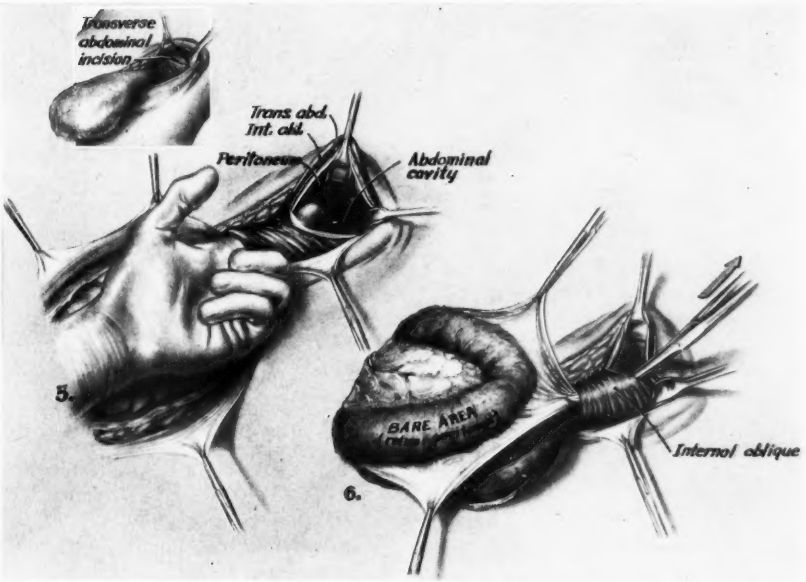

FIG. 3. The insert shows the position of the muscle splitting incision into the abdominal cavity. Step 5, A finger can be passed through the neck of the sac illustrating the continuity of the sac and peritoneal cavity. Step 6, The inversion is begun by passing a Kelly clamp through the muscle splitting incision and through the neck of the sac. By grasping the apex of the hernial sac reduction into the peritoneal cavity is begun.

neal dimple which provides a potential site for recurrence is obviated. The usefulness of the method of inversion was pointed out long ago by LaRoque, who advocated the method for operative cure of all inguinal hernias. Moschowitz, similarly, recognized the advantages of this procedure when he described the "rational treatment of sliding hernia." The method has since been amplified by numerous authors, often with slight modification, but the principles and objectives have been the same. From illustrations, it would appear feasible by the combined abdominal-inguinal approach to perform the inversion of the sac without ever opening the sac. In actuality, this procedure is not practical. In the first place, the sac has usually been opened before the diagnosis is discovered or substantiated, and in the second place, the reduction of the organ is made vastly easier after the sac has been opened. Reconstitution of the inverted sac is obtained after the intra-abdominal reduction has been effected.

METHOD

The usual inguinal hernioplasty incision is made and the anterior portion of the sac exposed and opened (Fig. 2). It is important that the opening be made anteriorly for one can enter inadvertently the sliding organ on the medial, lateral, and posterior aspects if the true nature of the hernia is not known. Once the sac is opened the diagnosis is easily made. There is a free wall of peritoneum anteriorly which has been incised. The hernial orifice can be explored with a finger leading into the peritoneal cavity, but on the posterior aspect there is nothing but the serosal surface of a retroserous organ. The anterior peritoneal portion is dissected free from the surrounding structures, and subsequently the bowel is likewise mobilized along its posterior aspect from the cord structures to a point well above the inguinal ring. One is careful in so doing not to injure the blood supply to the bowel which enters along the medial aspect. Actually, the mobilization of

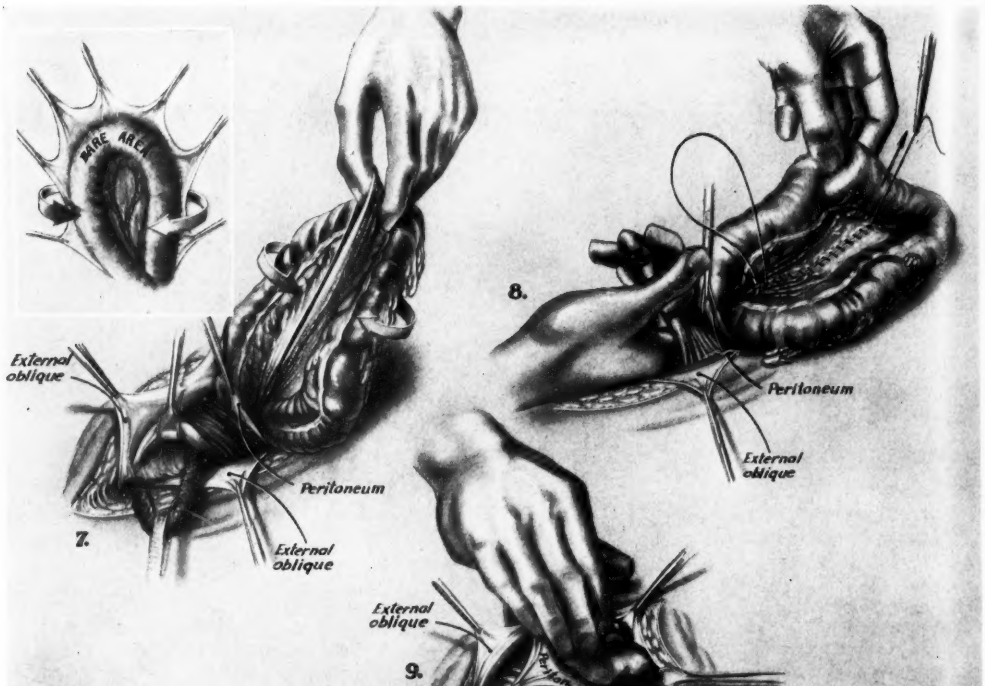

FIG. 4. Step 7, The sac has now been reduced into the abdomen and through the muscle splitting incision for the purpose of mechanically facilitating resuture of the inverted sac. The insert illustrates the condition of the superiorly directed sigmoid colon. What previously constituted the free anterior peritoneal surface of the hernial sac is visualized as a fringe of peritoneum suspended from the lateral margins of the gut. Step 8, The fringe is now turned inside out and sutured in a linear line to complete the inversion. By so doing it forms an anterior layer of the new free swinging mesentery. Step 9, The bowel is reduced within the abdomen and the muscle splitting incision closed.

the bowel posteriorly is an easy maneuver and is in no way different from mobilization of the right colon required in preparation for a right colectomy. Once the entire hernia, with its sliding organ, has been mobilized and separated from the surrounding structures, a muscle-splitting incision is made several inches above the inguinal ring through the same skin incision and the peritoneal cavity is opened (Fig. 3). One should avoid the iliohypogastric nerve and be well above the inferior edge of the internal oblique muscle so as to prevent further weakness in this area. Some operators have advocated the use of a complementary rectus incision in preference to the muscle-splitting incision. There is little or no reason to favor this approach, however. It provides no advantage in approach or visualization and, besides causing two scars, wastes time in its making and closing. The abdominal-inguinal approach now allows one to draw the viscus into the abdomen and thus to start the inversion of the opened sac which is readily accomplished by passing a Kelly clamp down through the muscle-splitting incision so that it emerges through the internal ring. The inferior apical edge of the sac is then grasped by the Kelly

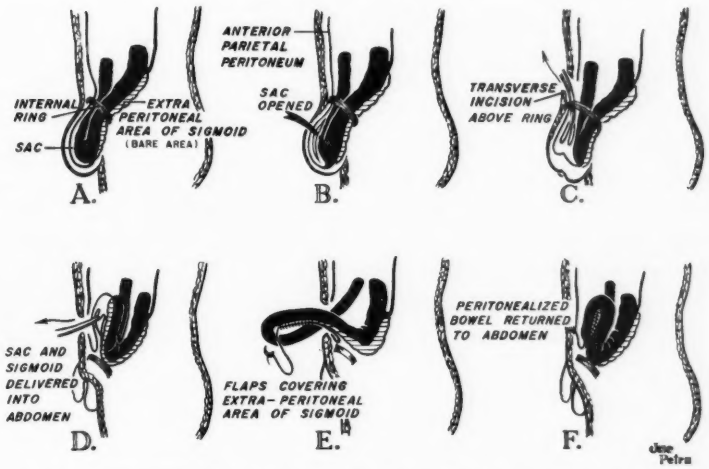

FIG. 5. This illustrates in diagrammatic form and in the sagittal plane the steps previously outlined. Notice how inversion allows the anterior peritoneal wall of the sac to be reconstructed as the anterior wall of a new mesentery for a free swinging sigmoid colon which before was tightly applied to the retroperitoneal wall.

clamp and by means of traction upward and by taxis from below the organ is reduced into the abdominal cavity. When this inversion is complete, what previously constituted the free anterior peritoneal surface of the hernial sac is visualized as a fringe of peritoneum suspended from the lateral margins of the gut (Fig. 4). The fringe is then turned inside out and sutured in a linear line so as to complete the inversion of the sac. At the same time it forms a free swinging mesentery for the bowel which heretofore has been fixed to the posterior abdominal wall. Brown advised anchoring some of these stitches through to the posterior half of the mesentery at an avascular area near its root. This procedure may help to flatten the anterior and posterior surfaces of the newly formed mesentery. The abdominal peritoneum and the muscles of the muscle-splitting incision are then closed and attention is again directed to the inguinal area. What a surprise to find how well above the inguinal area the inferior limits of the peritoneal cavity now project. The inguinal repair can then be performed by whatever method appears suitable.

There are certain natural inquiries into the foregoing procedure. "If the sac is merely inverted, why does it not re-form?" At least two factors operate to prevent this unfavorable result: (1) The hernial sac in its inverted position no longer has the tubular shape in which it was disposed when located in the scrotum; instead, it is flattened in an anterior-posterior plane like the walls of a balloon that is decompressed. The apex of this inverted sac (the term "sac" is now used with some misgiving since it is only potentially a sac) has suspended from its margins bowel whose lateral dimensions far exceed the diameter of this potential sac now acting as a mesentery. It would be a most unusual directional force which could invert the wide diameter of the bowel through the pliant and alterable axis of a collapsed sac whose walls lie in apposition to each other. (2) When the hernial sac is inverted from its position in the scrotum into the abdomen it is apparent that the serosal peritoneal surface is turned inside out. Thus the apposing surfaces of the superiorly directed mesentery or "superiorly directed sac" are placed raw surface to raw surface, and it is only a question of days before they are adherent to each other and the potential sac of which we speak is obliterated. (3) If concern still exists in the minds

of the operators as to the potential re-formation of the sac, Brown has suggested periodic suture of the anterior and posterior leaves of the newly formed mesentery as previously described.

DISCUSSION

The LaRoque method of repair for sliding hernia, then, fulfills all of the necessary requirements for adequate and complete obliteration of the sac and at the same time provides easy restoration of the sliding viscus to the normal abdominal confines. Were it not superior to, but merely on a par with other methods for repair from below, it would still provide ample advantage and justification for its use. Once the technique, perhaps confusing on the first or second attempt, becomes mastered even the most extensive and complicated sliding hernia is converted into a problem which can be accomplished simply, rapidly, and with dexterity.

To recapitulate, the problem in the management of a sliding hernia arises from the presence of an intra-abdominal viscus whose anterior serosal layer forms in part the posterior portion of the hernial sac. Because of this anatomic arrangement the usual treatment of the hernial sac, i.e., excision and high ligation, is impossible. The sac, however, can be eliminated by another maneuver, by inversion. The sac is turned inside out. When the inversion is completed the direction of the sac is reversed. Instead of projecting inferiorly the sac now projects superiorly into the abdomen. Furthermore, by means of this inversion of the sac the anterior peritoneum of the hernia is utilized to form an anterior peritoneal layer for a new mesentery which now suspends the previously amesenteric bowel freely within the abdomen. Elimination of the sac takes place by its conversion into a mesentery and by the fact that inversion places raw areolar surface to raw areolar surface, allowing the empty space (inverted sac) to obliterate rapidly by fusion.

SUMMARY

Sliding inguinal hernia occurs infrequently in the experience of most surgeons. Its unexpected appearance may confuse and perplex the operator unless he understands the character of its anatomy and development. The authors have attempted to stress the pathogenesis and to indicate in detail the technique of eliminating the sac by inversion. By such procedure the problem can be resolved with simplicity and expedition.

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CANCER OF THE THYROID GLAND IN CHILDREN

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CANCER NOW RANKS as one of the major hazards in children. In the number of deaths, it occupies the third place, exceeded only by accidents and pneumonia. One in every 14 deaths is due to cancer. Early symptoms in the younger age group should alert the pediatrician, who should always consider cancer in his differential diagnosis. Colloid goiter and functional enlargements at puberty are often seen. These are usually soft, uniform, and free from nodules. Other types of goiter may also be seen. In all cases they must be regarded as being more serious than those occurring in adult life. In the 10 year period between 1945 and 1955 the author operated on 1,000 patients with goiter in 40 of which carcinoma was present. Seven of these patients were in the younger age group, the oldest being 18 years of age. A total of 14 patients in this age group were operated upon so that the incidence of cancer was 50 per cent.

Studies should include basal metabolism and protein bound iodine tests. Roentgenograms of the chest and bones are obtained. Radioactive iodine uptake estimation together with the thyrograms are of the utmost value. If a filling defect is seen in the thyrogram, one should be more than ever suspicious of cancer (Fig. 10). It must be remembered, however, that these areas may be due to other causes, such as a cystic condition, an area of thyroiditis, or an adenoma. Certainly any area of firmness or nodularity is suggestive of malignancy. Any area in the neck where a firm nodule is palpated some distance from the thyroid must be suspected as metastasis. The day before operation an uptake dose of radioactive iodine is given. Following operation the thyroid tissue is fixed in formalin, put through paraffin, and sections are cut for microscopic examination. Some of the unstained sections are mounted on slides and then are exposed to a photographic film. A radioactive autogram is obtained by developing this film (Fig. 13). From this the amount of uptake of radioactive iodine into the tumor tissue may be estimated. It is of the utmost importance to know if the tumor tissue will absorb iodine, in case there is any metastasis. The papillary type absorbs iodine very poorly. The alveolar and mixed types take up iodine much better. Metastases often disappoint by their failure to take up iodine. However, if a total thyroidectomy has been performed and if all remaining thyroid tissue in the neck has been destroyed by the use of radioactive iodine treatment, the best conditions are established for increased activity in any metastasis. The natural thyrotropic hormone stimulation under these circumstances will bombard the metastasis in the absence of thyroid tissue in the neck. The metastases tend to become more active and to absorb more iodine. This property may also be stimulated or enhanced by the injection of thyrotropic hormone, which now may be obtained in crystalline form. It may also be noted that the same result may be obtained by giving thiouracil medicines.

It has been deemed necessary in the past to have the patient in a myxedematous condition during treatment. However, it has been suggested recently by Sturgeon and associates that it is not necessary to withhold thyroid medication. It is too early to pass on this opinion with authority until further lapse of time.

One of the cases in the present series was in a 5 year old boy first seen with a firm nodular goiter (Fig. 1). X-ray photographs of this boy's chest showed widespread metastases in both lungs (Figs. 2 and 3). Pessimism seems to be the key word when metastases occur, but the patient was most fortunate in

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FIG. 1. Case 1. Preoperative photograph of 5 year old boy who was first seen with a firm nodular goiter.

this instance since the metastases responded very well to radioactive iodine treatment, as may be seen in Figures 4, 5, and 6. An x-ray film taken 2 years postoperatively (Fig. 7) showed the lungs to be entirely free of metastasis. A roentgenogram taken 5 years postoperatively (Fig. 8) again showed the lungs to be clear and free from metastases. The last roentgenogram taken of this boy was in April 1956, at which time the lungs had remained free from metastases. Inasmuch as the boy was operated upon in 1950, his case represents a 6 year cure.

It has now been very well established that radioactive iodine cannot be relied upon as the sole agent in the treatment of thyroid cancer, since the tumor tissue does not take up iodine sufficiently well. Neither does the tumor yield to x-ray therapy. Therefore, adequate surgery is of the utmost importance and should be performed in every case. It is our opinion that the minimum operation should be complete thyroidectomy together with block dissection on the side of the neck on which the cancer occurred. If the glands in the neck are positive for metastasis, a radical resection is also performed on the opposite side. It is possible to operate upon the two sides at one time, but this procedure is unnecessarily radical. We prefer to wait a month before attacking the second side, and then usually the internal jugular vein is left. It is absolutely necessary to do a complete radical neck dissection since in many cases positive lymph nodes were found along the jugular vein right up to the base of the skull. In a previously reported series (2), 68 per cent of cases showed positive lymph nodes on the same side, and 25 per cent, positive lymph nodes on the opposite side of the neck. In a similar manner cancer was found in both lobes of the thyroid gland in 27 per cent of the cases. In our opinion there is no such thing as a true encapsulation of a cancer in the thyroid tissue. It has been observed on numerous occasions that while the original tumor in the gland seemed to be encapsulated yet metastases had already occurred to the lymph nodes. Angioinvasion has been seen in numerous cases and the importance of this finding has been greatly exaggerated. These patients usually continue to live and enjoy life without any evidence of distant metastasis. This observation seems to be the rule, and only in rare instances are distant metastases found. An example is Case 4, which now represents a 5 year survival without metastases. The finding, therefore, of angioinvasion does not deter us in the least from the conviction that adequate surgery in the neck is advisable. Complete and adequate gland resections are performed irrespective of whether or not lymph nodes can be palpated. It has been demonstrated on numerous occasions that positive nodes are found at surgery along the jugular chain and often along the esophagus or tucked under the clavicle. Conversely, nodes that are palpable may be hyperplastic and may not contain cancer.

Lymph nodes in the neck which contain metastases are in themselves a danger to the patient. Not only may the cancerous tissue grow locally and even invade surrounding tissues but also it may spread from these areas by either the lymph channels or the blood stream. It would seem obvious, therefore, that adequate neck resections should be consummated.

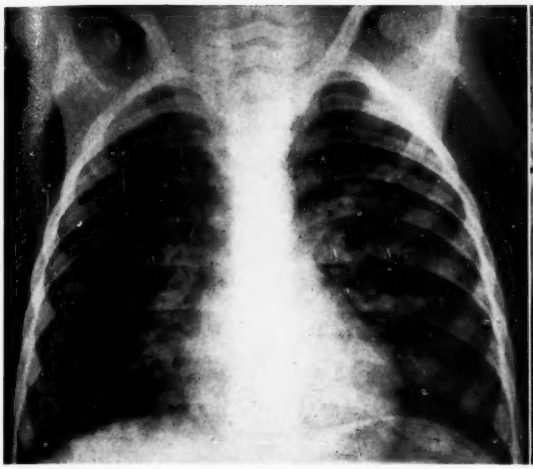

FIG. 2. Case 1. Roentgenogram taken January 10, 1950, shortly before surgery, demonstrates the "snow-storm" appearance of the metastases in the lung fields.

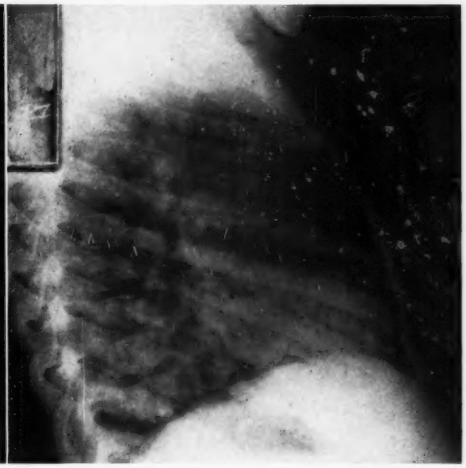

FIG. 3. Case 1. Lateral view of the chest, also taken January 10, 1950. The marked infiltration of the lung fields with metastatic carcinoma is shown.

Instead of curtailing these operations it would appear that the scope of surgery should even be enlarged. Since many of these tumors are not sensitive to either x-ray therapy or radioactive iodine, every possible endeavor should be made to eliminate cancerous tissue, whether it be in the thyroid gland or the lymph nodes of the neck. McClintock splits the sternum to enable thorough dissection of the superior mediastinum. We do not divide the sternum but do remove the lymph nodes and areolar tissue between the two carotid arteries down to the arch of the aorta. This can be done without splitting the sternum. This dissection is carried down along the innominate and subclavian arteries so that quite an adequate removal of glands from the upper mediastinum is performed. Also the esophageal chain of nodes which is often seen posterior to the recurrent laryngeal nerve is carefully dissected. The strap muscles are removed, since some lymph nodes are present between these muscles. As noted previously, a suprahyoid dissection is performed since positive glands often extend to the base of the skull along the jugular vein.

When the initial surgery is performed and a cancer is suspected, a lymph node is sought which may be sent for biopsy. It is unusual for a pathologist to be willing to give a report from a frozen section. Therefore a lobectomy is performed and the paraffin sections are awaited. If these show carcinoma a second operation must be performed consisting of a total thyroidectomy plus radical resection on the affected side of the neck.

CASE REPORTS

CASE 1. M. L., a 5 year old boy, was brought to us with a history of an enlarged thyroid gland for approximately 1 year. Both lobes were diffusely enlarged, firm, and nodular. There were no metastases palpable in the neck. Roentgenograms of the skeleton were negative. However, those of the chest showed diffuse mottling of both fields consistent with metastases. A total thyroidectomy was performed on January 18, 1950, and the pathologic diagnosis was adenocarcinoma.

A thyrogram taken postoperatively (Fig. 9) and following radioactive iodine treatment showed the thyroid gland to have been ablated completely and there was no abnormal area of uptake in the neck. He was kept in myxedema and was given radioactive iodine.

Roentgenograms of chest on March 30, 1950 showed marked clearing of the lung fields; on April 26, 1950 the lung fields were clear and free from metastases; on November 6, 1952 the lung fields remained free from any sign of metastases. A roentgenogram taken on January 5, 1955 again showed the lungs to be clear and free from metastases. An x-ray film taken on April

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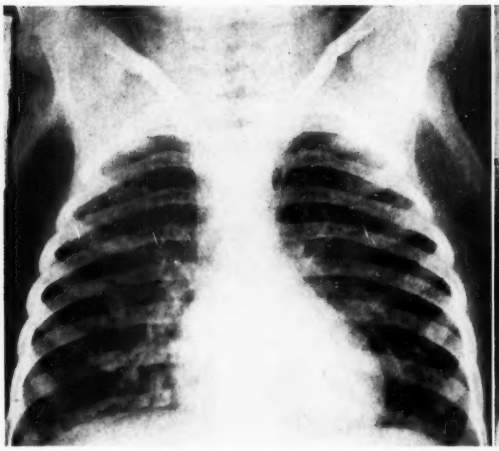

FIG. 4. Case 1. This roentgenogram taken March 30, 1950 shows a considerable reduction of metastasis occurring in the lung fields under radioactive iodine therapy.

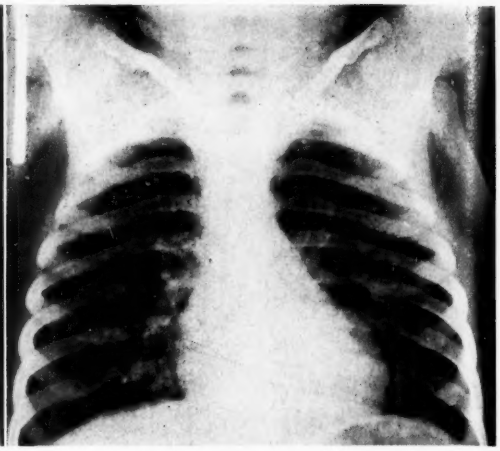

FIG. 5. Case 1. Roentgenogram of April 26, 1950 reveals that the metastases have steadily diminished under radioactive iodine therapy.

25, 1956, more than 6 years following operation, showed the patient to be entirely well and free from metastases.

CASE 2. D. P., a 15 year old girl, nervous and thin, was first seen on January 1, 1953. The thyroid gland on both sides was moderately enlarged and somewhat nodular. The nodules were small and firm. Lymph nodes could be palpated in the neck, particularly on the left side. X-ray films of the chest and bones were negative for metastases. The basal metabolic rate was plus 14; cholesterol 154; blood iodine 11.7 micrograms. A radioactive iodine study showed an uptake of 27 per cent. Thyrogram (Fig. 10) showed a normal distribution except in the palpable nodule in the isthmus which did not take up an appreciable amount. Prior to surgery, the patient was given another uptake dose to obtain a radioautograph. On February 23, 1953 a complete thyroidectomy plus a block dissection of the left side of the neck was done, keeping all tissue in continuity.

Pathologic study indicated that the isthmus was normal but that the left lobe contained several light gray nodules in the lower pole. The diagnosis was adenocarcinoma of the left thyroid gland with widespread metastases to the lymph nodes of the neck.

On March 30, 1953, a right neck dissection was performed, saving the muscle and jugular vein. Many

FIG. 6. Case 1. The lung fields, as shown in roentgenogram taken on November 17, 1950, are considered to be free of metastasis.

FIG. 7. Case 1. Roentgenogram, taken 2 years postoperatively November 6, 1952, reveals that the lungs are entirely free of metastases.

lymph nodes were found, enlarged and hyperplastic, but they did not contain cancer. A postoperative thyrogram (Fig. 11) showed that there was still an area of uptake of iodine. The patient was therefore given radioactive iodine treatment to ablate this area. A thyrogram taken on May 12, 1953 (Fig. 12) showed no areas of uptake in the neck, demonstrating that the radioactive iodine was successful in removing the area of uptake shown in the previous thyrogram (Fig. 11). A recheck on October 1, 1953 showed no residual uptake. A recheck on May 1, 1956 shows no evidence of cancer. The patient is being married.

This case represents the presence of a toxic goiter, and yet widespread cancer was present—a not infrequent occurrence (20 per cent or more).

CASE 3. J. H., a 7 year old girl had diffuse, firm enlargement of both lobes which was noticed 1 year ago and which had increased in size. On May 9, 1951 a total thyroidectomy was performed.

The diagnosis was diffuse papillary carcinoma in all sections of both lobes and isthmus. Subsequent test of radioactivity with a Geiger counter after injection of radioactive iodine showed that tissue in the thyroid bed was picking up radioactive iodine to some degree. The patient was given radioactive iodine to ablate any remaining thyroid tissue in the neck. A thyrogram on May 9, 1956 showed no residual thyroid and no metastases.

This case constitutes a 5 year survival without any evidence of metastases. The smooth diffuse character of the thyroid might well have been deceptive and this fact again emphasizes the importance of thyroid enlargements in children.

CASE 4. M. W., a 19 year old female, had a large, firm nodular goiter on the left side of the neck. Roentgenograms of the chest and bones were negative. Lymph node enlargements were clinically absent.

At operation on August 13, 1951 a complete thyroidectomy was performed. An encapsulated nodule of papillary adenocarcinoma was found in the left lobe. Blood vessel invasion was noted. The second operation on August 22, 1951 consisted of block dissection of the left side. Positive nodes were found extending up the base of the skull. Also deep nodes (positive)were seen and dissected behind the recurrent nerve along the esophagus. The sternomastoid was preserved, but the jugular vein was removed. A suprahyoid dissection was also done. On August 27, 1951 dissection of the right side of the neck was performed preserving muscle and vein. No positive nodes were found.

Radioactive treatment was given to ablate any remaining thyroid. On December 24, 1951 there was no

FIG. 8. Case 1. Roentgenogram taken on January 5, 1955 again shows that the lungs are clear and free of metastases.

uptake of iodine. On May 7, 1952 no evidence was present of any local recurrence or metastases as detected by a complete tracer study of the body. The keloid scar on the neck was responding to x-ray therapy. The patient was taking thyroid medication. On November 21, 1952 there was no palpable evidence of disease in the neck. Thyrogram showed no positive pick-up of the tracer in the thyroid or adjacent cervical areas. On May 27, 1953 the radioactive iodine uptake was reported as 0.6. Thyrogram showed no evidence of iodine concentrating tissue in the neck and palpation of the neck was negative. On February 25, 1954 there had been no recurrence. Repeated thyrograms showed no uptake in the neck. On June 13,

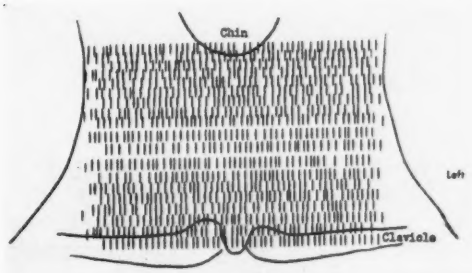

FIG. 9. Case 1. A thyrogram taken postoperatively January 2, 1953 and following the radioactive iodine treatment shows that the thyroid gland has been ablated completely and that there are no abnormal areas of uptake in the neck.

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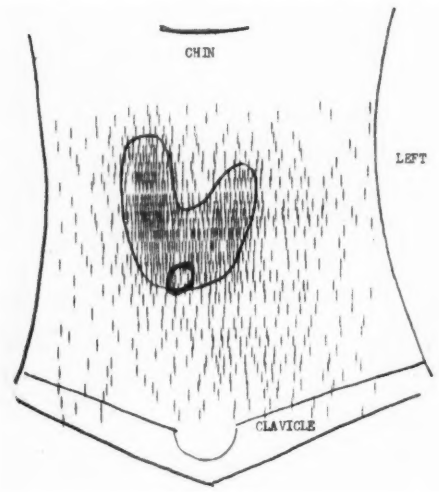


FIG. 10.

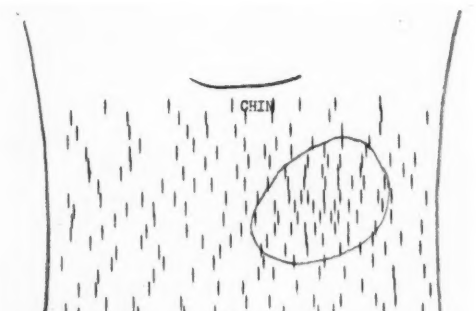


FIG. 11.

1956 there was no evidence of recurrence after a duration of 5 years.

This patient is free from metastases or recurrence after 5 years in spite of the presence of angioinvasion and lymph node metastasis. This finding attests to the value of adequate surgery and careful follow-up, using checks with radioactive iodine.

CASE 5. C. D., a 13 year old male, had a firm nodular enlargement of the right lateral lobe which seemed to extend into the isthmus. Firm lymph node enlarge-

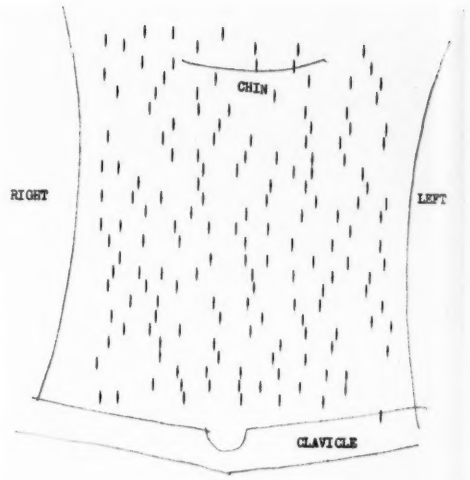


FIG. 12.

FIG. 10. Case 2. First thyrogram (preoperative) shows a reasonable uptake of iodine in both lobes and the isthmus. However, in the center of the isthmus there is an area which failed to absorb iodine. At operation this proved to be malignant.

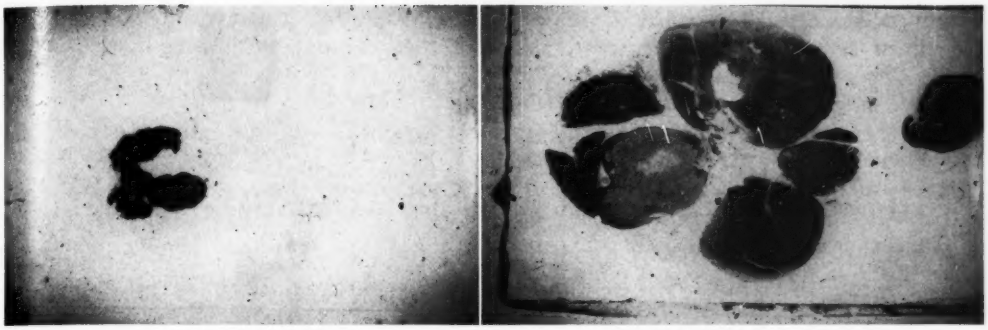
FIG. 11. Case 2. Postoperative thyrogram which shows that there is still an area of uptake of iodine. The patient was therefore given radioactive iodine treatment to ablate this area.

FIG. 12. Case 2. This thyrogram shows no areas of uptake in the neck, indicating that the radioactive iodine was successful in removing the area of uptake shown in the previous thyrogram (Fig. 11).

ments could be palpated on both sides of the neck. The preoperative diagnosis was carcinoma with metastases into the lymph nodes of the neck. A preoperative uptake dose of radioactive iodine was given so that a radioautograph could be obtained (Fig. 13).

Total thyroidectomy was performed on August 13, 1952. The parathyroids on the right were removed, but the left pair was preserved. A complete block dissection on the right side was also performed. Positive lymph nodes were found behind the right recurrent nerve, displacing it anteriorly. These nodes were removed. The sternomastoid muscle and the jugular vein were removed in the dissection. Positive nodes were found as high as the jugular foramen, so a complete suprahyoid dissection was done as well. On September 10, 1952, block dissection of the left side of the neck was performed, but the jugular vein was saved. A suprahyoid dissection was also done. Positive nodes were seen as high as the skull.

Pathologic diagnosis was: partly papillary adenocarcinoma of the right thyroid lobe and right half of the isthmus; metastatic adenocarcinoma of the lymph nodes on both sides of the neck.



a b

FIG. 13. Case 3. Sections of lymph nodes showing hyperplasia. a, One contains a tumor nodule with central fibrosis. The neoplastic tissue is glandular and forms some follicles with central colloid which fact suggests metastasis from a thyroid carcinoma. A radioautograph demonstrates uptake of radioactive iodine only in the foci of follicle formation and encircles the more solid fibrous cancer tissue in the center of the gland. b, Sections are seen in which iodine is taken up well where acini are filled with colloid. Where fibrosis is present, there is very little uptake of iodine. The conclusion must be drawn that radioactive iodine cannot be depended upon as the sole agent. There is a very definite need for careful and adequate surgery.

At follow-up examination the radioautograph showed a positive uptake of iodine which improved the prognosis in this case. On July 8, 1953, the thyrogram showed a very small uptake in the right lobe thyroid in the neck with no recurrence. On October 30, 1953 the thyrogram showed no recurrence and no uptake in the thyroid region. On February 18, 1954 the thyrogram showed no uptake except a small suspicious area near the isthmus. On August 13, 1956, thyrogram made with a larger dose was clear, showing no uptake in the thyroid area at all. Thus, after 4 years, the patient is entirely well, with no evidence of recurrence.

If the parathyroid glands are near the cancer tissue they should be removed. Otherwise they are left. This case constitutes a 4 year survival in spite of widespread lymph node metastases and angioinvasion. The results obtained again testify to the value of adequate surgery.

CASE 6. M. L., a 20 year old female with a preoperative diagnosis of adenoma of right thyroid lobe, was operated upon on February 13, 1948. A right lobectomy was performed. The lobe contained a well delineated and encapsulated nodule 2.3 centimeters in diameter. The pathologic diagnosis was Hürthle cell adenocarcinoma of thyroid. On February 22, 1956 there had been no recurrence.

The patient and relatives refused further surgery. In spite of this fact, she is well after 8 years.

CASE 7. N. C., an 18 year old female, had a small, firm nodule felt clinically in the left lobe of the thyroid gland. On December 19, 1949, a left lobectomy was performed. The nodule was in the center of the lobe and was surrounded by normal appearing gland tissue. The pathologic diagnosis was adenoma with areas suggesting low grade malignancy. On December 23, 1949 no lymph node metastasis could be felt clinically; nevertheless a block dissection of the left side of the neck was performed, saving the sternomastoid muscle. Positive glands were found widespread. The patient was given a thorough course of x-ray treatments following surgery. On August 17, 1951 dissection of the right side of the neck and right lobectomy were performed. The pathologic report was chronic lymphadenitis with no evidence of neoplasm.

The patient was married in 1952, and now has a child. When seen in February 1956 she had had no recurrences. This case represents a 7 year cure.

This case teaches that operation must be performed in the presence of firm nodules in the thyroid. Also palpation cannot be relied on to indicate if metastases have occurred.

SUMMARY

Cancer of the thyroid gland is a lethal disease. It does and will spread by invasion and by metastasis through the lymph vessels and via the blood stream.

The word "radical" should be left out of our nomenclature and the term "adequate surgery" be used instead. The minimum

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operation which could be called adequate is a complete thyroidectomy together with radical neck dissection on the affected side.

Any enlargement of the thyroid in the younger age group must be considered even more serious than in the older group. Fifty per cent of the patients operated upon in this age group had malignant disease.

The author wishes to emphasize the value of radioactive iodine as a complimentary agency to adequate surgery.

Case reports are given to illustrate our method of handling these cases.

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HYPOTHERMIA, LOW FLOW EXTRACORPOREAL CIRCULATION AND CONTROLLED CARDIAC ARREST FOR OPEN HEART SURGERY

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DIRECT VISION intracardiac surgery is now an established technical procedure, though the safest and most practical method of accomplishment is still unsettled. Extracorporeal oxygenation and circulation at flow rates equivalent to normal cardiac output would be ideal, but such flows are difficult to attain without expensive and complicated equipment. In nearly all high flow systems, almost prohibitive destruction to the blood components occurs requiring excessive amounts of anticoagulants. Low flow rates are easier to attain, but at normal temperatures, they may limit to a dangerous degree the intracardiac working time. Hypothermia requires very little special equipment and is easy to induce. On the other hand, marked cardiac irritability and the limitations of both the cold brain and heart to ischemia reduce the open heart period to a dangerously short interval. It occurred to us that the best features of both hypothermia and low flow perfusion could be combined for greater safety and simplicity. Earlier Gollan (3–5) and co-workers had reported extensively on the combination in the laboratory. To obviate any serious troubles with cardiac irritability, particularly when the ventricles are incised, a solution of potassium, magnesium, and prostigmine was found by means of laboratory studies that would induce easily controllable and reversible cardiac arrest (8, 10).

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The experience in this Clinic with 6 cases[1] in which moderate hypothermia was combined with low flow extracorporeal circulation is reported. In 1 case, induced cardiac standstill was added to extracorporeal perfusion and hypothermia.

METHODS

Hypothermia was induced by packing the patient in ice after induction of anesthesia. When a rectal temperature of approximately 34 degrees C. was obtained, the ice was removed and the operation started. The temperature drift usually carried the rectal temperature down to the desired levels of 30 to 31 degrees C. Pleural irrigations with hot or cold saline were sometimes used for lowering or elevating the temperature. Figure 1 shows the temperature variation in the patient B. A. L. during operation.

Extracorporeal circulation and oxygenation was obtained by a special system of plastic bag oxygenators (Fig. 2) and a pump described in detail in a previous report (1). Gas exchange in the bag was achieved by first filling the 1,200 cubic centimeter bag with 650 cubic centimeters of 100 per cent oxygen, and then rocking it back and forth until a total of 500 cubic centimeters of blood was collected. At the top, there is a snarl of plastic tubing to spread the blood along the wall of the bag. The interior of

[1]Since the submission of this article for publication, 11 more patients have had open heart surgery by this method. Five ventriculotomies using the potassium, magnesium, and prostigmine cardioplegic solution were accomplished. Ventricular fibrillation was prevented in all instances.

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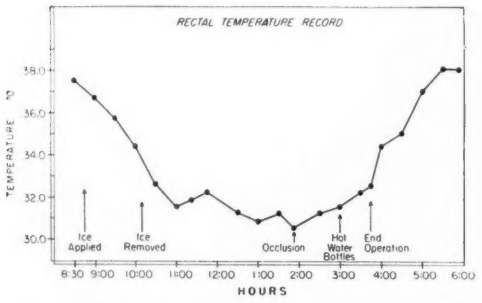

FIG. 1. Patient B. A. L. The temperature record during and after atriotomy. The recording obtained by thermocouple placed in the rectum.

the bags is lightly coated with a silicone defoamer. In these containers, 500 cubic centimeters of blood can be oxygenated to 100 per cent saturation in 2 minutes or less (1).

The inflow and outflow rates are monitored by constantly recording the weight of the blood on the arterial and venous side. This method makes it possible to perfuse at known inflow and outflow rates at all times. This system greatly simplifies compensation for blood loss at the operative site. A reservoir of 2,000 to 5,000 cubic centimeters of blood is needed. Venous blood is collected from the donors in the plastic bags each containing 15 milligrams of heparin in 50 cubic centimeters of isotonic saline containing 0.5 gram of glucose. Just prior to operation, 650 cubic centimeters of 100 per cent oxygen are introduced into each donor bag, and the blood is oxygenated as previously described.

Figure 3 illustrates how this system of oxygenation is accomplished during an actual operation.

In the 1 case of controlled cardiac standstill, 50 cubic centimeters of isotonic solution of magnesium sulfate and potassium citrate with the addition of .01 milligram of prostigmine per cubic centimeter were used. It was injected into the coronary circulation through the aorta, which was occluded just proximal to the innominate artery. The cardiac contractions were restored by allowing coronary perfusion of blood from the extracorporeal circulation to wash the solution from the heart.

Connection of the patient to the extracorporeal circulation was achieved by placing one of the outflow catheters into the inferior vena cava through the saphenous vein. The superior vena cava was intubated via the right subclavian vein. The inflow arterial connection was via the left subclavian artery. The catheters were oxygen catheters Nos. 12 to 14.

For anticoagulation, the patients were given 0.5 milligram of heparin per kilogram of body weight through the venous outflow catheter. The heparin effect after cessation of the extracorporeal circulation was neutralized by a 0.05 per cent solution of protamine sulfate in 0.85 per cent sodium chloride administered by a slow drip monitored by serial clotting times. The estimated protamine dosage was milligram for milligram of heparin taking into account that amount given in the donor blood. All of the latter was considered as having been administered to the patient. Table I shows the clotting times before and after perfusion in 2 patients. In all cases the clotting time returned to normal within ½ hour of starting the protamine drip, usually after administration of approximately one-half the estimated dose.

The anesthesia technique was well illustrated by the patient B. A. L. (Fig. 4). The preoperative medication consisted of 50 milligrams of pentobarbital, 1½ hours before anesthesia, followed by 35 milligrams of meperidine, and 0.2 milligram of scopolamine 1 hour before induction. Induction was with open drop divinyl ether followed by ethyl ether. Following orotracheal intubation, anesthesia was maintained with nitrous oxide and oxygen by utilizing a nonbreathing technique. Respirations were controlled manually throughout most of the procedure, which, including the refrigeration and rewarming, lasted 7 hours 15 minutes in patient B. A. L. Succinylcholine, 44 milligrams, was administered early in the anesthetic period to assist in abolishing spontaneous respiratory action.

Exposure of the heart was attained through an anterior bilateral intercostal incision. The fourth right and third left interspaces were used for the atrial defects. For the pulmonary and aortic valvulotomies, the fourth right and third left interspaces were used.

Figure 5 shows the electroencephalograms and electrocardiograms recorded at various intervals in patient B. A. L. Platelet counts and red cell survival studies were done and will be reported in detail later (6). Table II shows changes in platelets in 3 patients. Arterial hydrogen ion concentration, carbon dioxide tension, and oxygen saturation were determined at intervals throughout the procedure. Potassium and sodium determinations on arterial blood were also made. Table III summarizes the data obtained on patient B. A. L.

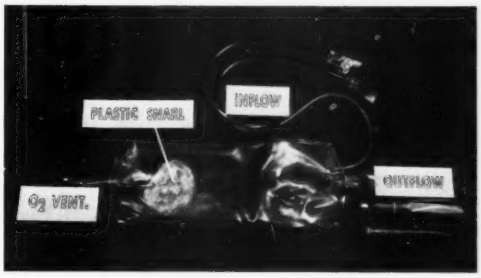

FIG. 2. This photograph demonstrates the various components of the plastic bag oxygenators. The plastic snarl is used to disperse the blood after it enters the bags. The inflow tubes have double connections, and one can be used for the entry of oxygen into the bag. The outflow tube contains a plastic filter.

RÉSUMÉ OF CASES

CASE 1. B. A. L., a 7 year old white girl, gave a history of a heart murmur since birth. The child's development had always been poor, and her activity had been markedly limited. On examination, there was a loud systolic pulmonary murmur transmitted in both directions across the chest. Cardiac catheter studies showed the pulmonary artery pressure to be 45/5 while a simultaneous femoral artery pressure was 140/80. There was a left to right auricular shunt of 5,455 cubic centimeters of 54 per cent of pulmonary flow. Roentgenograms showed large, full pulmonary arteries. Electrocardiograms showed incomplete right bundle branch block and right ventricular hypertrophy. On June 21, 1956, with extracorporeal circulation and hypothermia, a high interatrial defect was closed through a right atriotomy incision. Convalescence was satisfactory (Table IV).

CASE 2. D. R., a 24 year old telephone switchboard operator, gave a history of a heart murmur since the age of 3 years. At the age of 21 years, she noted definite shortness of breath on exercise. Her dyspnea had gradually increased, so that digitalization and sodium restriction were needed. A short episode of unconsciousness occurred a week before admission. Examination revealed a loud systolic murmur over the pulmonic area and a markedly enlarged heart. On x-ray examination the vascularity of the lung fields was greatly increased, and the right ventricle was enlarged. Electrocardiograms showed right ventricular hypertrophy and incomplete right bundle branch block. A pulmonary artery pressure of 35/16 millimeters of mercury and a radial artery pressure of 125/75 millimeters of mercury were found on right heart catheterizations. There was a left to right auricular shunt, and the catheter passed easily from the right auricle into the right pulmonary vein. On April 29, 1956, by use of hypothermia and extracorporeal circulation, the large defect in the lower atrial septum was closed through a right atriotomy incision. Her convalescence was uneventful.

CASE 3. L. B., a 15 year old girl, had been known to have a heart murmur since infancy. Her development had been normal. Examination showed a loud systolic murmur over the pulmonic area. X-ray examination showed diminished vascularity of the lung fields, but there was a large, full pulmonary artery at the hilum with right ventricular enlargement. Electrograms showed right axis deviation. On cardiac catheterization, the right ventricular pressure was 160/0, pulmonary artery 5/2, and radial artery 80/70. There was no left to right shunt. On June 20, 1956, by using hypothermia and extracorporeal circulation, the stenotic pulmonary valve was divided under direct vision through a pulmonary arteriotomy incision.

The patient's postoperative course was quite uneventful except for mild transient postoperative pericarditis.

CASE 4. R. E. B., a 15 year old male, had had heart trouble since infancy. His development had been retarded. At the age of 2 years, and until age 6, he had had episodes of unconsciousness of short duration. All of his life he had had very poor exercise tolerance. A year before admission, he again had repeated attacks of unconsciousness of short duration brought on by physical exertion.

Examination showed a very loud systolic murmur over the aortic area transmitted to the neck. Blood pressure was 92/70. Roentgenograms showed enlargement of the left ventricle. Left axis deviation was demonstrated on electrocardiograms.

On July 20, 1956, the patient had an open aortotomy for division of a congenital stenosis of the aortic

TABLE I.—POSTOPERATIVE CLOTTING TIME IN 2 PATIENTS FOLLOWING HYPOTHERMIA AND EXTRACORPOREAL CIRCULATION

Patient	*Minutes after end of pump period*	*Bleeding time* in minutes*	*Total heparin dosage, mgm.*	*Amount of protamine sulfate given after pump period, mgm.*
W.H.T.	0	More than 20	11 by vein to patient	150
	12	More than 20	150 in reservoir	
	32	10		
	87	5		
B.A.L.	0	More than 20	8 by vein to patient	75
	15	15	150 in reservoir	
	37	5		
	85	4		

*Lee-White method.

valve. Hypothermia with extracorporeal circulation was used. In addition to systemic venous occlusion, the pulmonary veins were occluded during the aortotomy.

The patient's postoperative convalescence was uneventful. An aortic diastolic murmur was noted after operation. His postoperative blood pressure was 119/60.

CASE 5. R. B. was a 16 year old white girl with the history of heart disease since birth. The patient had had moderate restriction of activity because of exercise tolerance, but she had never been in frank failure. On several occasions in the last 2 years, she had had episodes of dyspnea with some cyanosis.

Examination showed a very loud systolic murmur over the pulmonic area. Roentgenograms showed increased vascularity of the lung fields and right ventricular enlargement. Electrocardiograms showed right bundle branch block. A pulmonary artery pressure of 30/10 and right ventricular pressure of 35/2 were found on right heart catheterization. The catheter passed readily into the left auricle, and a large left to right shunt was demonstrated.

On June 27, 1956, by using hypothermia and extracorporeal circulation, a high interauricular defect was closed through a right atriotomy. The patient's postoperative course was uneventful.

CASE 6. W. H. T., an 8 year old negro boy, had had heart trouble since birth. He had had frequent episodes of cyanosis after exertion. Since the age of 3 years, he had been on digitalis. In the past 2 years, he had been getting progressively worse and was at complete bed rest for most of this time.

Examination showed a loud thrill and murmur over the pulmonic area. The blood pressure was 70/50. The patient was poorly developed. X-ray examination showed greatly increased vascular markings in the lungs with a large heart. Electrocardiograms showed combined hypertrophy of ventricles.

Cardiac catheterizations were difficult to interpret. Pulmonary artery pressures were 80/42, right ventricular pressure 80/0. Cuff measurement of the brachial arterial pressure was 80/60. The mixed vena cava oxygen content was 10.4 volumes per cent; high right auricle 12.1; low right auricle 12.4; low right ventricle 12.4; high right ventricle 13.0; and pulmonary artery 13.3 volumes per cent. The femoral arterial oxygen content was 14.2 volumes per cent and was 97 per cent saturated.

On July 3, 1956, a right atriotomy and right ventriculotomy were performed with closure of the atrial and ventricular septal defects, by using hypothermia and extracorporeal circulation. Induced cardiac standstill with potassium, magnesium, and prostigmine was used for the ventriculotomy. Cardiac arrest lasted for 15.8 minutes. Good forceful rhythmic contractions returned 30 seconds after release of the aorta clamp. The patient awoke from the anesthesia and was mentally alert. He maintained a normal blood pressure for 6 hours after surgery. Death occurred 12 hours after surgery from cardiac failure.

CASE 7. O. A., a 31 year old white female, was admitted with a history of a murmur since early childhood. Until the age of 9 years, the patient had recurrent bouts of arthritis of the extremities. At age 21, because of increasing dyspnea, edema, pericardial and pleural fluid, she was hopitalized and treated for rheumatic fever and cardiac failure. Since then, she has been going gradually downhill and, on admission to the hospital, was in mild failure.

Examination of the heart showed a loud systolic murmur and moderate diastolic murmur at the base. The neck veins were distended and the liver enlarged. X-ray studies showed marked vascularity of the lung fields with a greatly enlarged heart. The pericardium was calcified about the base and the posterior aspect of the heart. Electrocardiograms showed auricular fibrillation and right bundle branch block. Cardiac catheter studies showed a left to right shunt in the auricle with a mean pressure of 15 millimeters of mercury. The right ventricular pressure was 55/15, pulmonary artery pressure 55/20, and radial artery pressure 108/73.

On September 11, 1956 an exploration of the pericardium was done, and the patient did not have pericarditis. There were, however, large deposits of calcium in the pericardium as well as many adhesions. Two weeks later, a right atriotomy with repair of a septum primum defect was done. There were no postoperative complications.

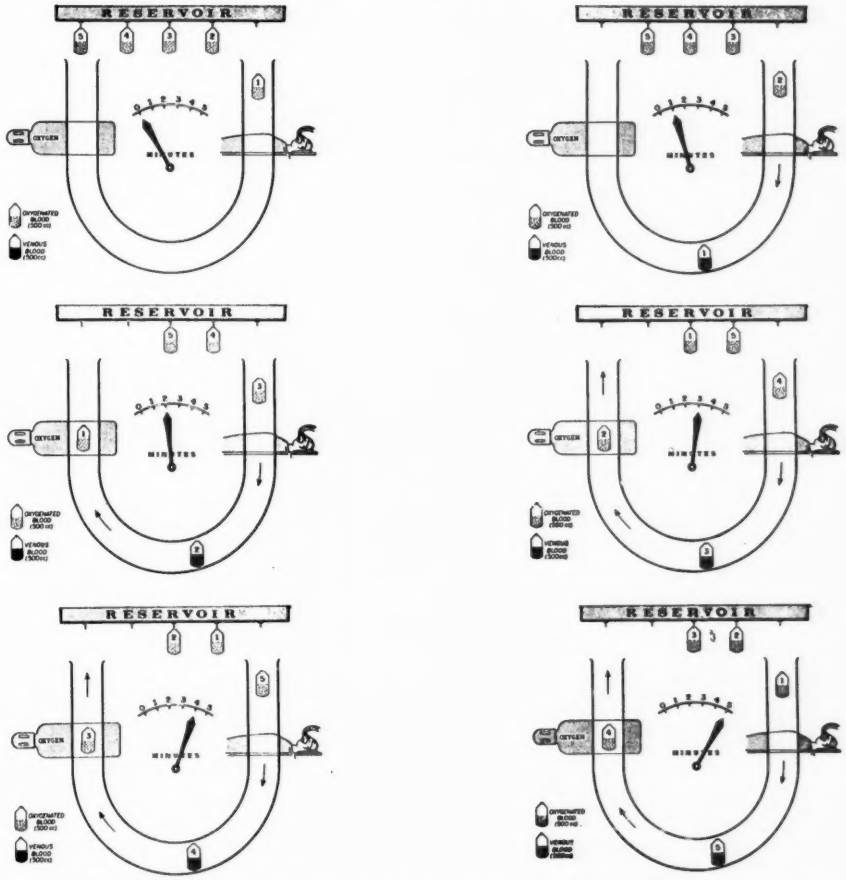

FIG. 3. This is a diagrammatic illustration of the time it takes to oxygenate and perfuse a patient with blood at 500 cubic centimeters per minute with our method of extracorporeal circulation. At the end of 3 minutes, an equilibrium is reached where 1 unit of 500 cubic centimeters has just been oxygenated, a second has started to be oxygenated, and a third unit of 500 cubic centimeters has started to perfuse the patient. There remain 2 units in the reservoir. This equilibrium is maintained. One thousand cubic centimeters could be perfused in the same way providing initial reservoir capacity of 5,000 cubic centimeters were available. The blood loss from the wound can be easily managed with this system merely by increasing or decreasing the inflow or outflow. The scales allow for easy monitoring of the inflow and outflow so that the exact flow rates are known.

DISCUSSION

In reports in the literature of open heart surgery, there are no accounts of the combination of hypothermia and low flow perfusion having been used on patients. There are certain advantages of a low flow rate extracorporeal system that are related directly to the lack of trauma to the blood elements from the slow turnover of blood in such a system. Simplicity in operation is the greatest virtue of any system as well as the most important single safety factor. Other things, such as initial cost, upkeep, and minimal number of personnel for operation, are also important considerations in the assessment of the advantages of various techniques. The method of extracorporeal circulation described fulfills these requirements.

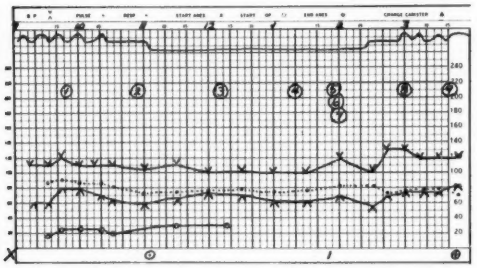

FIG. 4. This is the anesthesia record on patient B. A. L. The circled numbers represent the time the arterial blood samples were obtained from the indwelling arterial needle in the brachial artery.

TABLE III.—SUMMARY OF DATA OBTAINED ON PATIENT B. A. L. DURING HYPOTHERMIA, EXTRACORPOREAL CIRCULATION, AND CLOSURE OF ATRIAL SEPTAL DEFECT

Time	*Body temp., degrees C.*	*Arterial pH*	*Arterial pCO_2 mm./Hg*	*Arterial per cent sat.*	*Na mEq./L.*	*K mEq./L.*
9:50	35.0	7.51	27.95	100.0	155	2.9
10:55	31.4	7.50	25.40	100.0	152	3.7
12:10	32.4	7.63	17.80	98.0	157	2.6
1:20	31.0	7.58	18.60	98.0	151	2.8
1:54	30.5	7.44	25.00	100.0*	151	5.2
1:56	30.5	7.42	36.55	100.0*	162	3.2
2:00	30.5	7.43	32.90	98.5*	175	2.8
3:00	31.4	7.57	20.50	84.0	164	2.6
3:40	32.7	7.41	35.60	88.0	151	3.4

*Samples obtained during extracorporeal circulation. This actually represents determinations on reservoir blood.

The achievement by hypothermia of a 25 to 50 per cent reduction in the oxygen need of the body is from theoretic consideration an ideal metabolic state for the maintenance of heart and brain viability with low flow arterial perfusion rates. The principal objection to hypothermia for open heart surgery has been the irritability of the cold heart. In its markedly depressed metabolic state, yet with the heart still having to work against arterial resistance, the occurrence of ventricular fibrillation with increasing cold is not unexpected. If in addition to the low temperature, venous inflow occlusion is done, the heart is deprived of all of its blood supply. Though its work is reduced, it still has the work of contraction to do. Any manipulation of the ventricles of the cold, ischemic, contracting heart is understandably followed by ventricular fibrillation. Even the low flow rates to the coronary circulation achieved by extracorporeal perfusion undoubtedly are of great protection to the heart after inflow occlusion. This, we believe, is the greatest factor in the maintenance of normal heart beat in our series. Limitation of hypothermia to temperatures not less than 30.0 degrees C. has been an additional important factor in preventing severe arrhythmias.

TABLE II.—PREOPERATIVE AND POSTOPERATIVE PLATELET COUNTS IN 3 PATIENTS FOLLOWING HYPOTHERMIA AND EXTRACORPOREAL CIRCULATION

Name	*Preoperative platelets per cu. ml.*	*Postoperative platelets per cu. ml.*
B.A.L.	250,000	150,000
L.B.	247,500	175,000
R.B.	195,000	162,000

Our observation on the changes in the electroencephalogram after inflow occlusion, with subsequent improvement on arterial perfusion, clearly indicates the protective effect on the brain of small arterial perfusion rates (Fig. 5).

A third maneuver for increasing the safety of open cardiac surgery is absolute control of the cardiac contractions. It is much better to prevent than treat ventricular fibrillation. Procedures upon the right atrium are usually short and nonirritating even to the moderately hypothermic heart, and myocardial blood supply does not have to be compromised. Ventriculotomies, however, are frequently followed by serious arrhythmias in the cold heart. The necessity for periods of coronary occlusion for adequate vision may further aggravate the irritability. The necessity of continued coronary perfusion for the contracting heart after ventriculotomy makes operation of an extracorporeal circuit more complex and interferes with intracardiac manipulation. It also may be the source of considerable blood loss as pointed out by Kirklin. When the left atrium or the left ventricle is opened, a still heart reduces the possibility of air emboli in coronary arteries. Laboratory studies on the action of a cardioplegic solution containing potassium, magnesium, and prostigmine have been published (10). Our observations (8) of the iso-

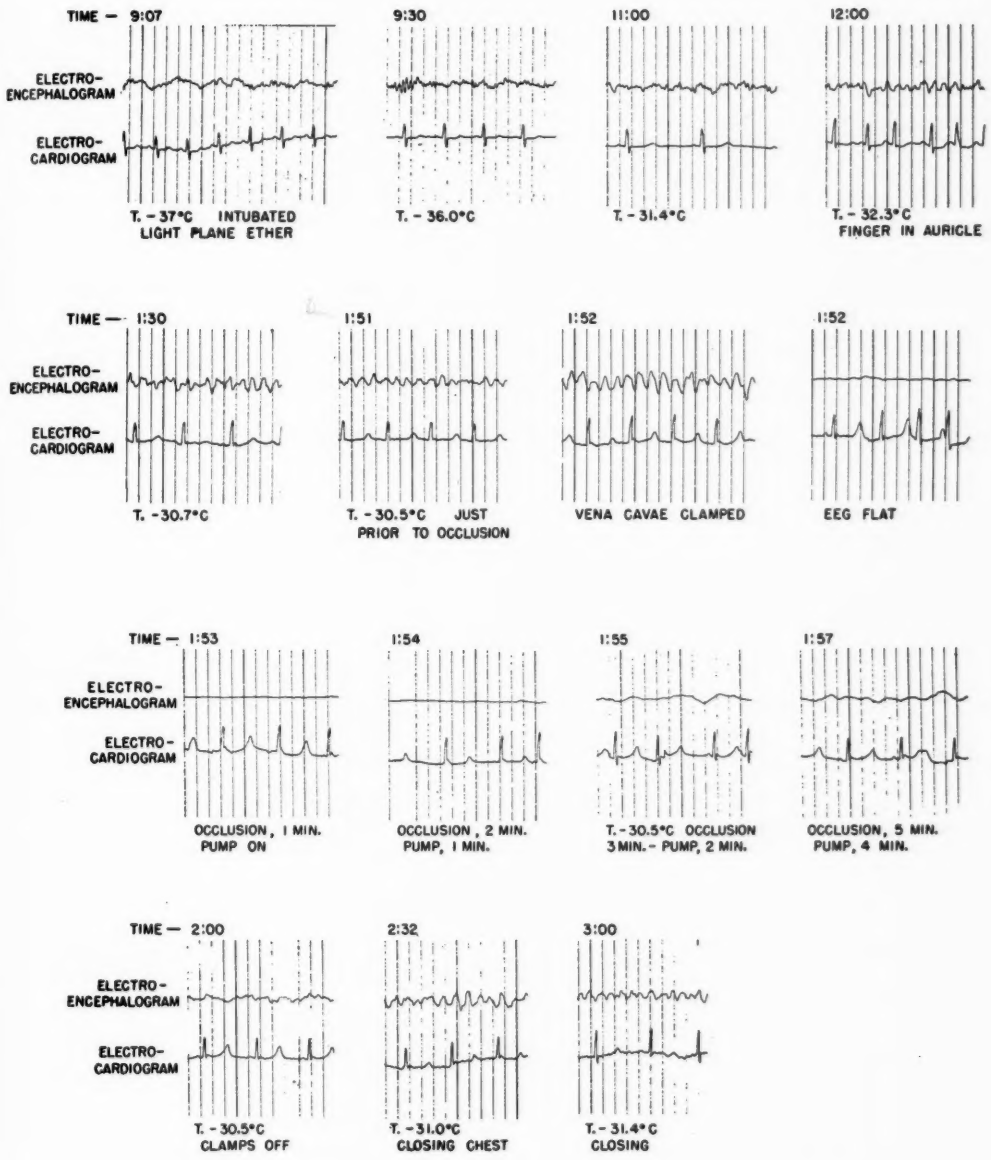

FIG. 5. Patient B. A. L. This is a reproduction of the frontoparieto-occipital lead of the electroencephalograph and lead II of the electrocardiograph. There was a sudden loss of electroencephalographic activity in 15 to 30 seconds after vena caval occlusion. Between 1 and 2 minutes after starting pump rates of 35 cubic centimeters of blood per kilogram of body weight per minute, the electroencephalogram improved, and improvement continued for the entire pumping period.

TABLE IV.—DATA ON 7 PATIENTS UNDERGOING OPEN HEART SURGERY OR AN ARTERIOTOMY FOR SEMILUNAR VALVE STENOSIS WITH EXTRACORPOREAL CIRCULATION AND HYPOTHERMIA

Patient	*Sex* *Age, yrs.* *Wt., kgm.*	*Diagnosis*	*Operation*	*Flow rate, c.c., per kgm. body wt.*	*Perfusion time*	*Inflow venous occlusion time*	*Rectal temp. C.*	*Comments and results*
B.A.L.	F 7 17.2	Atrial septal defect	Closure of high atrial septal defect	35 (600 c.c. per min.)	7.10	5	30.7	Good
D.R.	F 23 56	Atrial septal defect	Closure of low atrial septal defect	14 (800 c.c. per min.)	11	6	29.9	Good
R.B.	F 16 30	Atrial septal defect	Closure of low atrial septal defect	17 (500 c.c. per min.)	7.15	4.6	30	Good
R.E.B.	M 14 35.5	Congenital aortic stenosis	Division of aortic valve	17 (600 c.c. per min.)	7.3	6	31.4	Good. Aortic occlusion and coronary flow stasis for 3.5 min.
L.B.	F 15 41.5	Congenital pulmonic stenosis	Division of pulmonic valve	19 (800 c.c. per min.)	4.5	4	30.5	
W.H.T.	M 11 23	Atrial septal defect	Closure of atrial septal defect	22 (500 c.c. per min.)	5	4	31	*Induced cardiac standstill for 15.8 min. Contractions in 30 sec. Regained consciousness. Normal blood pressure for 6 hours.
		High ventricular septal defect	Closure of ventricular septal defect	26 (600 c.c. per min.)	20	19		Died 12 hours after operation from pulmonary hypertension.
O.A.	F 31 40	Septum primum atrial defect	Closure of atrial septal defect	14 (550 c.c. per min.)	16	14.1	31	Good

*Potassium-magnesium-prostigmine solution.

lated cold cat heart and the intact hypothermic dog indicate that this solution is superior to either potassium or magnesium alone. In the intact animal, the two electrolytes are effective in such low concentration that toxicity is not a problem. In the intact animal, the cold heart frequently fibrillated after release from standstill induced by potassium. The prostigmine in the solution as noted by Montgomery acts in slowing the heart rate in the very critical poststandstill period.

In patient W. H. T., the three techniques of low perfusion rates, moderate hypothermia, and controlled cardiac standstill have been used. The safety of the manipulation of the cold heart was borne out by the absence of fibrillation during ventriculotomy and the restoration of the heart beat to normal after restoring coronary perfusion.

We have kept the cold heart in standstill and ischemic for 31 minutes in the dog and 17 minutes in man. A noncontracting heart requires very little oxygen as has been demonstrated in our laboratory studies (10). It is our present estimate that the safe tolerance of cardiac standstill with ischemia at temperatures of 30 to 32 degrees C. is between 15 and 30 minutes. The experience of Effler with the normothermic heart tends to confirm this. The final evaluation of this method of controlled cardiac arrest awaits further experience, particularly in large hearts resulting from rheumatic fever and valvular disease.

It is of special note that the patient with an open aortotomy, which meant complete coronary arterial stasis in a beating heart, tolerated the latter for 3½ minutes at the temperature of 30 degrees C. The extracorporeal circulation as well as the pulmonary venous reservoir gave instant perfusion of the coronary system after the aorta was closed.

The efficiency of our method of extracorporeal circulation has been shown by this experience. The question of the time that one can keep up large flow rates by this method is illustrated in Figure 2. At rates of 20 to 40 cubic centimeters per kilogram of weight, we have carried a 23 kilogram patient (W. H. T.) through 21 minutes of per-

fusion at 26 cubic centimeters per kilogram per minute. This was in spite of considerable loss through the open heart from a faulty venous catheter and occluding tape. This same patient had a separate period of 5 minutes of perfusion for closure of an atrial defect. The patient regained consciousness.

Flow rates above 20 to 40 cubic centimeters per kilogram have been limited in large patients by the output of the standard size finger pump. Larger bags, double our present ones, would be another factor that would increase greatly the margin of safety in this system.

The minimal flow rates when combined with hypothermia for survival without cerebral damage are not known. From our unpublished laboratory reports, we believe that a flow rate of 15 cubic centimeters per kilogram of body weight is safe for 10 to 15 minutes, 30 cubic centimeters per kilogram for 15 to 20 minutes, and 40 cubic centimeters per kilogram for a period of 20 to 30 minutes.

During these procedures, the state of the central nervous system has been monitored with the electroencephalogram. The preocclusion pattern was that seen in light planes of anesthesia. The second, third, fourth, and fifth patients underwent inflow occlusion for about 1 minute before the extracorporeal circulation was begun. After occlusion, the sudden cessation of all electrical activity was rather terrifying, but the return of some activity, 1 to 2 minutes after the start of the extracorporeal circulation, was reassuring. The normal preocclusion pattern did not return until 15 to 20 minutes had passed, or until normal circulation had been re-established for about 10 minutes.

In patient B. A. L. (Table III), at the time of occlusion there was a drop in the hydrogen ion concentration from the alkalotic levels to normal levels. This could have been from the infusion of the donor reservoir blood that had not been subjected to hyperventilation. The patient W. H. T. showed a drop in p_H from 7.6 to 7.25 after a long pumping period at low flow rates. The metabolic acidosis was most likely the result of low flow rates and tissue hypoxia. It is not yet definitely established whether or not hypothermia will allow greater tolerance to this metabolic change.

The absence of any difficulty with bleeding in any of these patients is worthy of comment (Table I).

We believe that the absence of foaming and minimal trauma to venous blood with this system of oxygenation makes it possible to obtain adequate anticoagulation with only a very small amount of heparin. The effect of heparin has been easily neutralized by a dilute protamine solution which accounts for our complete lack of postoperative bleeding problems.

Three people are required for operation of this method of extracorporeal oxygenation and perfusion: one to collect and oxygenate the blood, one to man the arterial inflow side, and a third to monitor the entire procedure. The accompanying diagram (Fig. 3) shows the time necessary for oxygenating and exchanging blood at 500 cubic centimeters per minute. With the present size of our plastic bags, rates above 1,000 cubic centimeters per minute might be difficult to attain because of the rapid handling that would be required. We hope to report in the future on the use of bags larger than the ones now in use. The transfer times in the diagram are based upon the oxygenating time of 2 minutes for 500 cubic centimeters of blood.

SUMMARY

Six patients who had either open atrial, ventricular, or semilunar valve surgery are reported. Open heart surgery was accomplished by the use of hypothermia and extracorporeal circulation. In 1 case of right ventriculotomy, controlled cardiac arrest was employed.

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THE RESULTS OF THE TREATMENT OF CANCER OF THE BREAST AT THE MONTREAL GENERAL HOSPITAL

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THE EVOLUTION of present day treatment of carcinoma of the breast began with Moore of London in 1867 who was dissatisfied with the high local recurrence rate from simple mastectomy; thereupon, he conceived of en bloc removal of the breast and, if involved, of the adjoining skin and axillary contents to prevent cutting through tumor tissue. Volkmann in 1875 devised the operation of simple mastectomy followed by removal of the fascia of the pectoralis major muscle. Heidenham excised the superficial fibers of the pectoralis major muscle and Halstead removed the entire pectoralis major muscle. Willy Meyer added the pectoralis minor muscle to the dissection.

It remained for Halstead to clarify the principle of bloc dissection. The impact of this principle has dominated the treatment of carcinoma generally for the past 60 years.

Another concept which began in Halstead's time was developed by Sampson Handley (11) who on histologic evidence taught that carcinoma spreads centrifugally from its point of origin, chiefly by lymphatic permeation and occasionally by blood stream. In addition, Handley believed that the anterior mediastinal glands were not involved as early and as consistently as the axillary glands; therefore, in the early part of this century, the treatment of mammary cancer was directed at the axilla as it was considered to be the primary site of spread.

Keynes in 1922, impressed by the results of radium therapy for recurrent carcinoma of the breast, began to extend its use to include advanced primary cancer and later still, operable cancer. By 1940, with greater knowledge and experience, radiation therapy in high tumor doses was applied.

McWhirter of Edinburgh (1940 to 1950), impressed by the efficacy of simple mastectomy and postoperative radiation therapy, was even more convinced after seeing the report of R. S. Handley and Thackray (10), which dealt with the frequency of involvement of internal mammary lymph nodes especially for tumors of the medial half of the breast. McWhirter felt positive that with axillary node involvement, surgical dissection into the axilla spread the cancer; hence his statement "Surgery is unlikely to be successful unless supplemented by radiotherapy." Ackerman evaluating McWhirter's cases at Edinburgh commented on the additional treatments such as immediate ovarian sterilization, excision of nodes, and hormonal therapy—all of which complicated the apparently good results. The controversy between McWhirter's technique and a well-planned radical mastectomy as outlined by Haagensen and Stout continues. The critical comparative analysis of the 5 and 10 year survival rates using these two forms of therapy has led to four basic observations that are revising our present day treatment: (1) low absolute cure rate of carcinoma of the breast with any form of treatment; (2) frequency of involvement of the internal mammary chain and supraclavicular nodes; (3) high local recurrence rate in large tumors in which surgical excision has been either simple or radical[1]; and (4) surgical spread of tumors. Many animal experiments have shown that manipulation undoubtedly disseminates tumor cells.

Research workers, statisticians, objective surgeons, and pathologists have done much to clarify the present day status of cancer of

[1]Personal observations.

the breast and to dampen any undue optimism. The general impression left is that radical or simple mastectomy either with or without postoperative radiation therapy adds very little to the 5 and 10 year survival rates. The extreme opinion of Park and Lees is that treatment is completely ineffectual in improving survival rates. These reports have been a stimulus to produce better results and the most recent trend is in the form of a more radical attack by two different means: (a) Urban, Wangensteen, and Erhenhaft have devised supraradical surgical procedures. (b) Richards and Janes of the Toronto group have been promoting high dosage preoperative radiation followed by radical mastectomy for "locally advanced" operable carcinoma of the breast. The rationale of such therapy is ably stressed by Ash, Peters, and Delarue. Delarue and Pisani independently have published 5 and 10 year survival rates for "operable carcinoma" using high dosage preoperative radiation therapy, and the results have shown a definite improvement over radical mastectomy with or without postoperative radiation therapy.

The Montreal General Hospital tumor clinic recently introduced this more radical form of therapy to a few patients. A short term follow-up will be presented but 5 and 10 year survival rates await evaluation and will be reported at a later date.

From 1940 to 1950 at the Montreal General Hospital, radical mastectomy with and without postoperative radiation therapy constituted the two main forms of treatment for "operable" breast cancer. These as well as other modalities of therapy are recorded and evaluated in terms of 5 year survival from the date of treatment. For the purpose of comparing our results with other clinics, the three main classifications are used and their interpretation using the "retraction" and "invasive" phenomena as determining factors (outlined by the Toronto group) are as follows: retraction—adherent to skin or underlying muscle; invasive—fixed to deep tissue or ulceration of skin.

STIENTHAL CLASSIFICATION

Stage
- A. Movable tumor alone.
- B. Tumor with or without retraction phenomena plus axillary nodes.
- C. Tumor with invasive phenomena with or without axillary nodes plus distant metastases.

PORTMANN CLASSIFICATION

Stage
1. Movable tumor alone.
2. Tumor with or without retraction phenomena plus axillary nodes.
3. Tumor with invasive phenomena with or without axillary nodes.
4. As above plus distant metastases.

RICHARDS CLASSIFICATION

Stage
1. Movable tumor alone.
2. Movable tumor plus axillary nodes.
3. Tumor with retraction phenomena with or without axillary nodes.
4. Tumor with invasive phenomena with or without axillary nodes.
5. As above plus distant metastases.

DISCUSSION AND CONCLUSIONS

In spite of the several modalities of treatment (I to X inclusive as shown in Table I), statistical analysis[2] allows us to compare only the two main forms of therapy, i.e. radical mastectomy alone (I) as against radical mastectomy plus postoperative radiation therapy (II). The standard radical mastectomy, outlined by Halstead and Meyer, was meticulously performed, and if postoperative radiation therapy followed surgery, 1,000 to 2,000 roentgens over a period of 2 weeks was the minimum tumor dose applied.

Analysis of the Stienthal classification (Table I) reveals no significant difference in 5 year survival rate for "operable" breast cancer (stages A and B) for the two main forms of therapy (I and II).

The Portmann classification for stage 3 cancer shows a significant difference in 5 year survival rate of treatment I versus treatment II, i.e., radical mastectomy alone with a 75 per cent 5 year survival rate is superior to radical mastectomy plus postoperative

[2]Statistical analysis by G. I. Paul of the Department of Genetics, McGill University, Montreal.

TABLE I.—STIENTHAL CLASSIFICATION OF RESULTS OF THERAPY FOR CANCER OF BREAST IN 123 CASES RECORDED AS 5 YEAR SURVIVALS AT MONTREAL GENERAL HOSPITAL

Stage	*I*	*II*	*III*	*IV*	*V*	*VI*	*VII*	*VIII*	*IX*	*X*
A										
Treated, No.	13	3		4						
Survivals, No.	10	2		3						
Survival rate, per cent	77	66		75						
B										
Treated, No.	23	47	5	3	1		3	2	1	1
Survivals, No.	17	35	3	3	0		0	1	0	1
Survival rate, per cent	74	74.5	60	100	0		0	50	0	100
C										
Treated, No.	1	1	1	1	1	4	7			1
Survivals, No.	1	0	0	0	0	0	0			0
Survival rate, per cent	100	0	0	0	0	0	0			0

I, Radical mastectomy alone.
II, Radical mastectomy and postoperative x-ray.
III, Preoperative x-ray and radical mastectomy.
IV, Simple mastectomy and postoperative x-ray.
V, Preoperative x-ray and simple mastectomy.
VI, Simple mastectomy.
VII, Radiation alone.
VIII, Modified radical alone.
IX, Preoperative x-ray and modified radical.
X, Modified radical and postoperative x-ray.

TABLE II.—PORTMANN CLASSIFICATION OF RESULTS OF THERAPY FOR CANCER OF BREAST IN 123 CASES RECORDED AS 5 YEAR SURVIVALS AT MONTREAL GENERAL HOSPITAL

Stage	*I*	*II*	*III*	*IV*	*V*	*VI*	*VII*	*VIII*	*IX*	*X*
1										
Treated, No.	13	3		4						
Survivals, No.	10	2		3						
Survival rate, per cent	77	66		75						
2										
Treated, No.	19	38	4	3	1		1	1	1	1
Survivals, No.	14	38	3	3	0		0	0	0	1
Survival rate, per cent	73.7	86.8	75	100	0		0	0	0	100
3										
Treated, No.	4	9	1				3	1		1
Survivals, No.	3	2	0				0	1		0
Survival rate, per cent	75	22.2	0				0	100		0
4										
Treated, No.	1	1	1	1	1	4	6			
Survivals, No.	1	0	0	0	0	0	0			
Survival rate, per cent	100	0	0	0	0	0	0			

TABLE III.—RICHARDS CLASSIFICATION OF RESULTS OF THERAPY FOR CANCER OF BREAST IN 123 CASES RECORDED AS 5 YEAR SURVIVALS AT MONTREAL GENERAL HOSPITAL

Stage	*I*	*II*	*III*	*IV*	*V*	*VI*	*VII*	*VIII*	*IX*	*X*
1										
Treated, No.	13	3		4						
Survivals, No.	10	2		3						
Survival rate, per cent	77	66		75						
2										
Treated, No.	5	10								
Survivals, No.	1	9								
Survival rate, per cent	20	90								
3										
Treated, No.	14	28	4	3	1		1	1	1	1
Survivals, No.	13	24	3	3	0		0	0	0	1
Survival rate, per cent	92.8	85.7	75	100	0		0	0	0	100
4										
Treated, No.	4	9	1				3	1		1
Survivals, No.	3	2	0				0	1		0
Survival rate, per cent	75	22.7	0				0	100		0
5										
Treated, No.	1	1	1	1	1	4	6			
Survivals, No.	1	0	0	0	0	0	0			
Survival rate, per cent	100	0	0	0	0	0	0			
Total										
Treated, No.	37	51	6	8	2	4	10	2	1	2
Survivals, No.	28	37	3	6	0	0	0	1	0	1
Survival rate, per cent	75.7	72.5	50	75	0	0	0	50	0	50

TABLE IV.—STIENTHAL CLASSIFICATION OF 5 YEAR SURVIVALS, CORRELATED WITH SIZE, AXILLARY NODE INVOLVEMENT, SITE, AGE, AND DURATION OF SYMPTOMS

	Size, cm.		*Axilla*		*Site*		*Age, years*			*Duration of Symptoms, mos.*	
Stage	*Under 4*	*4 or more*	*Not involved*	*Involved*	*Inner half*	*Outer half*	*Under 40*	*40–60*	*Over 60*	*Under 6*	*6 or more*
A	73.3	100.0	83.2		63.6	82.6	100.0	73.9	84.6	72.7	83.3
B	79.5	51.6	100.0	60.0	58.8	76.3	70.0	76.2	54.0	72.0	56.0
C	0.0	0.0		0.0	0.0	0.0		0.0	0.0	0.0	0.0
Totals											
Treated, No.	72	51	43	70	31	72	14	66	50	69	52
Survivals, No.	53	21	37	33	17	48	11	44	24	47	24
Survival rate, per cent	73.6	40.4	86.0	47.0	54.8	66.0	78.5	66.0	48.0	68.0	46.0

radiation therapy with a 22.2 per cent survival rate (5 year).

The results in Richards classification (Table III), unlike those in the Stienthal and Portmann classifications reveal a difference in the 5 year survival rate with treatments I and II and these are as follows: (a) Radical mastectomy plus postoperative radiation therapy (II) with a 90 per cent 5 year survival rate for stage 2, is superior to the 20 per cent survival rate of radical mastectomy alone (I). (b) The Portmann classification supports the Richards classification in revealing the superiority of radical mastectomy alone for invasive carcinoma with or without axillary lymph nodes (stage 3). (c) The Richards classification with its finer clinical staging, in contrast to the Stienthal and Portmann classifications points out the superiority of combination therapy (II) for stage 2 carcinoma (i.e., for carcinoma with axillary spread but with no retraction phenomenon). True, the possibility of clinical error using the Richards classification is increased but with experience, a more accurate appraisal of the extent of disease can be made against which the results of treatment can be tested.

A review of Table IV demonstrates again that the 5 year survival rate increased with decrease in the size of the tumor, that it decreased with axillary node involvement, and improved for the outer quadrant lesion. In age group breakdown, however, our results differed from those of Delarue and Smith in that the patients in the 40 to 60 year age group had a favorable 5 year survival rate (76.2 per cent, stage B) and this result was without ovariectomies. With the much discussed factor of the effect of delay of treatment on the survival rate, we have found a more favorable prognosis with early treatment. For stage B (Stienthal classification) 72 per cent of patients survived 5 years if treated within 6 months of the onset of symptoms; whereas, only 56 per cent of patients survived 5 years if treatment was delayed for more than 6 months from the onset of symptoms.

For 123 cases (Table V), the total 5 year survival rate from the onset of symptoms, irrespective of the type of treatment and including inoperable cases was 68.3 per cent. This is against the 22.5 per cent 5 year survival rate from the onset of symptoms with no treatment, as reported by Daland. Thus we cannot concur with Park and Lees that

TABLE V.—SUMMARY OF SURVIVALS IN 123 CASES AT MONTREAL GENERAL HOSPITAL (1940 TO 1950)

	Per cent
Total 5 year survival rate from date of treatment	62.6
Total 5 year cure* rate from date of treatment	38.8
Total 5 year survival rate from onset of symptoms	68.3

Note: These figures include "inoperable" cases.
*No persistence or recurrence of the tumor at 5 years.

TABLE VI.—RESULTS OF PREOPERATIVE HIGH DOSAGE RADIATION THERAPY

		Alive and well in 1956			
Year treated	*No. treated*	*No.*	*Survival rate, per cent*	*Cure rate, per cent*	*Microscopic examination of breast and axilla 3 to 6 months after preoperative radiation therapy*
1953	4	3	75	75	Residual cancer cells in all
1954	6	6	100	100	4 specimens—no residual cancer cells 2 specimens—residual cancer cells
1955	4	4	100	100	Residual cancer cells in all

treatment is completely ineffectual. Treatment, and especially early treatment, alters the 5 year survival rate favorably.

However, the 35.8 per cent 5 year cure rate (no persistence or recurrence of disease) points out the inadequacy of our treatment from 1940 to 1950 in completely eradicating the disease and justifies our hope in the new and more radical attempts to produce cure.

From Table I, only 6 cases (1940 to 1950) were treated by preoperative radiation therapy followed by radical mastectomy—too few to be significant. Since 1953, the tumor clinic at the Montreal General Hospital has embarked on a program of giving high dosage preoperative radiation therapy (6,000 to 7,000 r., M.T.D.) over a period of 2 to 3 months). This therapy is followed in 3 to 6 months (varying with radiation reaction) by standard radical mastectomy. The results shown in Table VI, although admittedly short term, reveal that in 14 cases, there has been only 1 death from carcinoma and the remaining 13 patients show no evidence of persistence or recurrence of their disease.

In a follow-up of these 14 cases, there have been no untoward reactions during and immediately after the radiation therapy. Most of the trouble has been in the postoperative phase with delayed wound healing. Of the 14 patients only 1 has shown severe radiation necrosis of the skin of the chest wall, and this was covered adequately with a large pedicle tube graft in the reconstructive surgery department. The tangential method and increasing technical skill precludes extensive pulmonary fibrosis. In the early phase of this more radical form of treatment, however, our sentiments are ably expressed by Adair, "It yet remains to be seen whether the good effects attributable to preoperative radiation therapy in heavy doses justify the increased morbidity." The proponents of high dosage preoperative radiation therapy believe that the complications of this form of therapy have been overemphasized.

It is of interest (Table VI) that in the 14 patients treated by high dosage preoperative radiation therapy (7,000 to 8,000 r.) only 4 patients (28.5 per cent) were free of carcinoma by microscopic examination. Grill, studying histologically the effect of preoperative radiation therapy in 20 cases, found 5 cases (25 per cent) in which tumor cells were not detectable in removed specimens. Grill concludes that preoperative radiation of carcinoma is beneficial from the standpoint of prevention of local recurrence or metastases.

SUMMARY

1. The changing concepts in management of breast carcinoma are presented.

2. Treatment, especially early treatment, improves the 5 year survival rate considerably.

3. The relatively low 5 year cure rate (35.8 per cent) justifies our hope in the recent and more radical advances in breast cancer therapy.

4. Except for patients in stage 2 (Richards classification) postoperative radiation therapy in dosages of 1,000 to 2,000 roentgens (M.T.D.) in 2 weeks adds no significant improvement to the 5 year survival rate over radical mastectomy alone.

5. The Richards classification gives the more accurate clinical appraisal of the extent of disease against which the various modalities of therapy can be tested.

6. Patients in the age group of 40 to 60 years show a favorable 5 year survival rate (76.2 per cent) in spite of no ovariectomies.

7. Short term results give a good indication of the effectiveness of high dosage preoperative radiation therapy.

8. Preoperative radiation therapy in doses of 6,000 to 7,000 roentgens (M.T.D.) over a period of 3 to 6 months sterilizes the breast and axilla of carcinoma cells in 25 to 30 per cent of cases. The superior results claimed by some, if found consistent, may justify the increased morbidity chiefly in the form of delayed wound healing.

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THE APPLICATION OF ARTERIALIZED VENOUS BLOOD TO INTRACARDIAC SURGERY

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CONTROLLED CROSS CIRCULATION using the principles of reduced "azygos" flow demonstrated that open intracardiac surgery was not only possible but was also feasible even in critically ill patients (6, 18). The application of this method resulted in the cure of many children with congenital malformations of the heart not previously amenable to corrective surgery (7, 9-11).

The knowledge and experience gained in the 45 patients operated upon with controlled cross circulation led to the development of the reservoir technique (8, 19, 20) which eliminated the direct donor. The practicability of this latter procedure, which was first applied clinically in March 1955, was enhanced considerably by the use of arterialized venous blood in the perfusion. Moreover, in the subsequently developed pump oxygenator (2, 3, 12) arterialized venous blood has been found to be valuable as a source of fresh oxygenated blood for priming of the apparatus.

It has been known since the work of Meakins and Davies (15) in 1920 that small samples of blood essentially arterial in oxygen content could be withdrawn from the veins after heating of the arm. This study presents a detailed summary of the optimal conditions for the application of this phenomenon to the collection of larger quantities of such arterialized blood from the veins of donors for use in perfusion methods permitting intracardiac surgery.

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TECHNIQUE FOR COLLECTION OF ARTERIALIZED VENOUS BLOOD

All studies have been made on human blood obtained from donors attending the blood bank of the University of Minnesota Hospitals. Prior to phlebotomy, the hand and forearm on the side to be bled were warmed for 10 to 15 minutes with either wet or dry heat and with the patient sitting. At first the donors' arms were heated in cylinders of hot water. Later on in the study, a sink of running water was used to obviate the necessity for intermittent replenishment with hot water. Phlebotomy was performed with the donor supine, hot packs being applied to the arm to maintain heat. A few studies have been made with an electrically heated gauntlet encasing the hand and forearm. These warmed arms were kept at the highest temperature that could be comfortably tolerated; this temperature was found to be between 45 and 47 degrees C. After the arm had been suitably heated, a size 16 needle was inserted into a vein at the antecubital fossa either with or without the use of a tourniquet. An effort was made to identify and use superficial veins draining the hand. Frequently, however, such veins were not available and the antecubital vein itself or one of the deeper veins was used. Between 500 and 600 cubic centimeters of blood were collected from each donor into standard siliconized bottles or plastic bags containing 30 cubic centimeters of 5 per cent glucose solution or normal saline and 18 milligrams of heparin. Blood was allowed to drain by gravity occasionally supplemented with up to 5 pounds per square inch of suction from a Stedman pump. Care was taken to avoid foaming produced by excessive agitation of

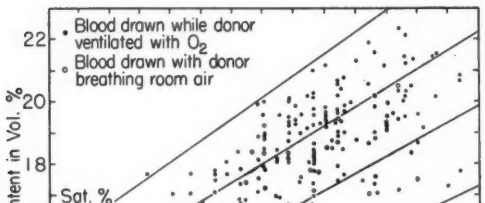

FIG. 1. The oxygen content and saturation of 200 units of blood drawn from the veins of human donors whose arms were warmed to 46 degrees C.

the bottles. Most of the donors were encouraged to breathe 100 per cent oxygen from a mask for some minutes just before and also during phlebotomy. Each bottle of blood was carefully mixed and aseptically sampled by using a closely fitting oiled syringe. This blood was used for analysis of oxygen content, oxygen capacity, carbon dioxide content, hydrogen ion concentration, and hemoglobin. Gas contents were analyzed in duplicate 1 cubic centimeter aliquots within 4 hours by the method of Van Slyke and Neill. The syringes containing the samples were kept in ice water between sampling and measurement. Hydrogen ion concentration determinations were made at 37 degrees C. using a microelectrode immersed in a waterbath. Hemoglobin was determined colorimetrically. All blood collections were made on the morning of operation because, although stored blood retains its oxygen content, the platelet and possibly other clotting factors tend to deteriorate steadily with time. Donors were found willing to attend the blood bank early in the morning before the start of their work, and thus the patients received the benefit of fresh blood with its superior hemostatic qualities. The blood was kept in a waterbath at 37 degrees C. between the time of collection and actual use (up to 4 hours) while cross matching took place. The use of blood at body temperature during perfusion is important as both under experimental and clinical conditions, the efficiency of the heart action has been seen to deteriorate rapidly coincident with the infusion of cooled blood.

RESULTS

The aim of this study has been to assess the similarity of large quantities of venous blood drawn from the veins of previously warmed arms to arterial blood. Certain preliminary work was performed to define those experimental conditions which could be used to arterialize maximally the venous system of the arm without causing undue discomfort to the donor. The latter consideration was of practical importance in facilitating the continued use of this method by the blood bank personnel.

The necessary time for immersion of the hand and forearm was determined in 3 volunteers. Samples of blood were drawn at 1 minute intervals from the superficial cubital vein during immersion of the hand and forearm in hot water at a temperature of 46 degrees C. The venous oxygen saturation was found to increase rapidly at first and later more slowly, finally reaching a plateau at about 8 minutes. As a result of this study, an arbitrary immersion time of 10 minutes was used in all the later work. Withdrawal of blood while the donor sat warming his arm was terminated because of the occurrence of light-headedness or syncope in nonprofessional donors. Prolonged heating, even without phlebotomy, was avoided because it led to diaphoresis, generalized vasodilation, and occasionally even fainting. Warming of the arm with an electrically heated glove, although simpler, did not prove as efficacious as wet heat because even distribution of heat could not be as readily attained.

Both clenching of the fist and pumping of the forearm were avoided since they tended to result in a lower oxygen saturation either by decreasing blood flow through the hand or increasing muscle flow. The use of a tourniquet during blood collection was con-

sidered unwise at first because of its possible interference with flow and its trapping action in the deep muscular veins. However, in practice it did not appear to have a significant effect on the oxygen saturation and was used in the great majority of these collections. A tourniquet was not usually required for the venipuncture as the veins were engorged by the greatly increased flow, but it did facilitate phlebotomy. Breathing 100 per cent oxygen increases the total oxygen content of blood by an increased increment in dissolved oxygen proportional to the increase in partial pressure. Most of the donors breathed 100 per cent oxygen just before and during phlebotomy for this reason.

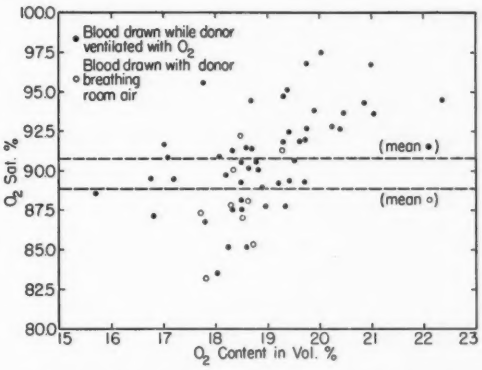

FIG. 2. The oxygen content and saturation of the mixed priming blood used in the oxygenator reservoir at the first 59 intracardiac operations. Lines indicate the mean values for the "warmed arm" vein blood drawn with and without the donor breathing oxygen.

CLINICAL EXPERIENCE

Collections have been made from human donors producing a total of 225 units of arterialized venous blood for clinical use; the results of this study are based on the data obtained from analysis of each sample. The first 45 bottles were drawn with the donors breathing room air, the last 180 units being obtained during ventilation with oxygen. The hemoglobin concentration, oxygen content, and oxygen saturation of the last 200 bottles are illustrated in Figure 1. The oxygen saturations ranged from 70 to 100 per cent with the majority of the values falling around 90 per cent. The mean values for all the chemical determinations performed on these bottles of blood are shown in Figure 2. The hemoglobin concentrations, hydrogen ion concentrations, and carbon dioxide contents for blood drawn with and without oxygen are practically identical, both with each other and with the accepted normal values for arterial blood (p_H7.42, carbon dioxide content 21.9 mM./L.). However, ventilation of the donor with oxygen raised the average per cent saturation of the arterialized venous blood from 83.2 to 88.5, the oxygen content rising by 1 volume per cent. Sixty-two intracardiac procedures have been performed by using venous blood drawn in this manner. The first 3 trials were made with the reservoir technique. A description of the clinical use of this method has already been published (8, 20). In 1 of these reservoir perfusions, the patient was successfully maintained by the use of arterialized venous blood during a total cardiopulmonary by-pass interval lasting 52 minutes.

The last 59 collections of arterialized venous blood have been used to prime the bubble oxygenator. In most cases, 2 units of blood were required to fill the oxygenator reservoir; however, higher perfusion rates require up to 4 bottles. As a convenient working rule, the volume of arterialized venous blood required to prime the oxygenator reservoir prior to starting the perfusion has been found to be approximately equal to the flow rate for 1 minute. Thus a priming volume is best correlated with the patient's size and the perfusion rate. To provide blood containing a high oxygen content in spite of the variability in degree of arterialization found in the donor units, some selection was necessary. Out of the 225 bottles collected, only 152 were considered suitable for use in priming. These bottles were selected on a basis of actually measured oxygen content or by their color. By this means, the average oxygen saturation of the blood used in priming was 90.8 per cent when the donors

TABLE I.—MEAN VALUES FOR VARIOUS METABOLIC CHARACTERISTICS OF ARTERIALIZED VENOUS BLOOD DRAWN WITH THE DONOR WARMING HIS ARM FOR 10 MINUTES PREVIOUS TO BLEEDING

Donor ventilated	*No. of bottles*	*Hemoglobin, gms. per cent*	*O_2 content, vols. per cent*	*O_2 capacity, vols. per cent*	*CO_2 content, mM./L.*	*pH*	*Oxygen saturation, per cent*
Air	45	15.4	17.3	20.8	22.3	7.43	83.2
	27*	15.4	18.3	20.6	23.2	7.43	88.8
Oxygen	180	15.6	18.4	20.8	22.5	7.44	88.5
	125*	15.5	18.8	20.7	22.7	7.43	90.8
Total	225						
	152* (68%)						

*Units selected for priming of the oxygenator or reservoir.

breathed 100 per cent oxygen and 88.8 per cent when the donors breathed room air. Table I shows the hemoglobin concentration, oxygen content, and saturation of the oxygenator-reservoir blood during 59 actual cardiac by-pass operations. The remaining units of blood were used to replace coronary venous return and other losses occurring during the open cardiotomy.

DISCUSSION

Meakins and Davies (15) first showed in 1920 that small samples of blood having an oxygen content essentially the same as that normally found in the arteries could be withdrawn from the veins after heating the forearm and hand. In a later communication, they reported on a similar resemblance between the carbon dioxide contents of arterial and arterialized venous blood (14). These observations were confirmed by Barcroft and Nagahaski. Goldschmidt and Light (4) found as have others later, that the average oxygen saturation of antecubital venous blood is normally about 70 per cent with a range of 25 to 85 per cent, whereas samples drawn from veins on the back of the hand have a mean of 87.7 per cent. These investigators (8) showed that venous blood in the hand became arterial above a critical ambient temperature of 44 degrees C. The higher oxygen saturation of venous blood draining from the hand was attributed to the low metabolic activity of skin and bone, the predominant tissues in the hand, the presence of arteriovenous communications, and the heat regulating properties of this organ. The latter two circumstances resulted in a markedly increased flow in response to heat (calculated to be fifty-fold).

A number of workers have shown that the capillaries of the skin, finger pulp, and lobe of the ear contain arterial blood after heating. It has been suggested that these sources might be used for diagnostic purposes and thus avoid the need for arterial puncture. However, the difficulty in collecting adequate samples, under anaerobic conditions, by finger prick led to the proposal by Webner and Cooper of using arterialized venous blood collected from veins on the back of the hand. Our experience has been almost entirely with arterialized blood drawn from the antecubital veins. In 1 instance, a bleeding was undertaken from veins in the hand with apparently excellent results. Veins at the elbow were used to facilitate the accepted blood bank procedure and to enable heating of the hand to be continued during the phlebotomy.

Previous work, as mentioned before, has established the fact that heating induces arterialization of capillaries in the skin and veins on the back of the hand, but reports on the oxygen saturation of antecubital venous blood drawn during heating of the arm are meager and conflicting. Early studies on isolated cases appeared to demonstrate essentially arterial saturation (93 or 94 per cent) however, Goldschmidt and Light (5) showed that although the mean of 5 individual samples gave a saturation of 92 per cent, the range was 86 to 97 per cent. Their observation of a lesser degree of arterialization at the elbow as compared to the hand veins has been confirmed recently in a small

number of cases. Our preliminary studies like the earlier work cited were made on only a few individuals and gave a somewhat optimistic view of the degree of arterialization to be expected in the antecubital veins after heating of the arm (16). The presently reported studies on a large number of donors with the collection of much greater volumes of blood emphasize the variability in the observed response. Thus, while the majority of the oxygen saturations are arterial in nature, about 15 per cent of the values fall below 80 per cent saturation. These results have necessitated selection of units of blood for priming and prompted investigations upon the effect of having the donors breathe oxygen during bleeding.

The use of this "hot arm" blood for priming the artificial oxygenator reservoir and arterial tubing has proved valuable in human perfusions despite its occasional suboptimal saturation since it may be conveniently arterialized to full oxygen content by running it through the oxygenator first. Such blood has a superior hydrogen ion concentration and carbon dioxide content for arterial perfusion compared to blood drawn from unheated arms and similarly passed through the machine.

The nature of the variability in oxygen content is of some interest. After cutaneous heating, the veins of the hand are uniformly arterialized, but a variable decrease in oxygen saturation occurs by the time the blood reaches the elbow. Admixture with blood arising from muscular drainage areas deep in the forearm undoubtedly is the cause of this change. At the elbow it is difficult to puncture veins draining exclusively the hand as occasionally all superficial forearm veins are absent. The oxygen saturation of blood returning in superficial forearm veins may be lower than that found in the deep vessels. These anatomic considerations explain some of the variability found. However, at rest the amount of blood returning from the forearm muscles is normally only a fraction of the flow through the hand, and heating will greatly increase this disproportion. Individual differences or varying ambient or emotional conditions may limit the usual increase of blood flow through the hand after heating because of a congenital or acquired reduction in the number of arteriovenous communications or perhaps more likely because of the persistence of an exaggerated vasomotor tone. Recently, evidence has been obtained to show that optimal local heating certainly does not cause a vascular paralysis as once believed, inasmuch as a further increase in hand blood flow was obtained by reflex vasodilatation brought about by distant heating.

SUMMARY

Studies have been made of the arterialization of antecubital venous blood after immersion of the hand and forearm in water at 46 degrees C. for 10 minutes. This phenomenon has been used to collect 225 units of blood for use in the priming of either reservoir or oxygenator systems for human intracardiac surgery.

The hydrogen ion concentration and carbon dioxide content of this blood, collected into heparin, have been found to be identical to the normal values for arterial blood.

The majority of the oxygen contents of such arterialized blood have averaged around 90 per cent saturation; however, 15 per cent of the values are below 80 per cent saturation.

The reasons for the variability in the degree of oxygenation have been discussed and measurements have been made upon the effect of having the donors in addition breathe oxygen during the phlebotomy.

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NONUNION OF TROCHANTERIC AND SUBTROCHANTERIC FRACTURES

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NONUNION of trochanteric and associated subtrochanteric fractures is rare but when encountered presents a major surgical problem. Because it is rare, little has been written on this subject. Nutter and Pohlidal reported 1 case of nonunion, with a method of treatment; Cleveland, Bosworth, and Pietra, 4 cases in their series; and Moore Moore, Jr., 1 case; Taylor, Neufeld, and Nickel reported 15 cases of delayed union. Our impression is that nonunion may follow open reduction and internal fixation of trochanteric fractures more often than it follows closed methods of treatment. Since the majority of acute trochanteric fractures in this country are now treated with internal fixation (and we believe for good reason), nonunion may occur more frequently.

This study is based on a series of 28 patients, of whom 14 were referred to the Campbell Clinic for the treatment of nonunion and 14 developed nonunion under our care. In patients treated for acute trochanteric fractures by the Clinic staff, the rate of nonunion is between 1 and 2 per cent.

Of the 28 patients studied, 15 were male and 13 female. In a series of 300 trochanteric fractures previously reported (2), 75 per cent of the patients were female. From these data it might be inferred that nonunion is more frequent in males, but the present series is too small to warrant such a conclusion. In the previous report, the majority of patients (representing 39.7 per cent of all patients studied) were between 70 and 79 years of age, while the mean age in the present group was 47 years. This difference tends to substantiate our clinical impression that nonunion is more apt to occur in a younger age group.

Of the 28 patients studied, 22 were initially treated by open reduction and internal fixation. Five were treated by traction: 3 with balanced skeletal traction, and 2 with Hoke-Martin well leg traction. The remaining patient, because of multiple injuries, was treated by bed rest and sandbags. The average length of time between the fracture and the diagnosis of nonunion was 9 months.

Two types of trochanteric fractures are more prone to develop nonunion: those associated with a subtrochanteric fracture, and those associated with a fracture of the base of the neck of the femur. If absorption of bone occurs about the fracture site, the nail-plate may tend to hold the fragments apart, thus predisposing to nonunion. When nonunion is developing, coxa vara occurs, causing bending or breaking of the nail-plate or screws, loosening of the internal fixation, or a combination of these factors. The result is instability and pain in the hip, and shortening of the limb. The patient and often the surgeon attribute the nonunion to the breaking of the nail-plate. But the reverse is usually true: i.e., the nail-plate breaks because nonunion is developing. Eight patients in this series had a broken nail-plate, and 3 had broken screws.

In some patients with nonunion of a trochanteric fracture, surgery is not indicated, usually because of the patient's general medical situation. In the present series of 28, six patients were not operated upon. One developed a postoperative infection following the original operation for the acute fracture. Two were senile. The other 3 patients died: for 1 of these, the cause of death was unknown; the second died of primary carci-

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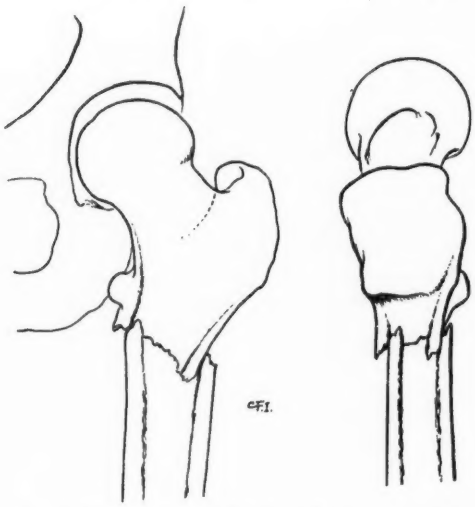


FIG. 1. Method of obtaining the valgus position of the hip and the overriding of cortices.

noma of the liver; and the third was killed in an automobile accident.

Twenty-two patients were operated upon for nonunion, 4 of whom are discussed in detail later. Twenty of them had only 1 operation, following which union occurred: in 3 of these 20, the ends of the fragments were freshened and a renailing performed; in the other 17, bone-grafting operations were performed. Of the 2 remaining patients, one had 2 bone-grafting operations, and the other (Case 4) had 4, before union was obtained.

Twenty-three bone-grafting operations were performed on 19 patients. Autogenous bone alone was employed in 7 operations, homogenous bone alone in 7, and autogenous and homogenous bone were mixed in 9. The homogenous grafts were of two types: ordinary frozen bone, and freeze-dried bone from the tissue bank of the United States Navy, Bethesda, Maryland. Because of the high percentage of unions and the small number of cases, no valid conclusions about the value of the various types of bone can be drawn from this series.

The average follow-up was 28.6 months after the last or only operation for nonunion; the longest was 9 years. A long term follow-up study was not attempted, because most of these patients were discharged after union was obtained.

TREATMENT

Nonunion in these fractures may be treated by several methods. One of the best begins with removal of the internal fixation (if any) and excision of the scar tissue at the fracture site, thus freshening the ends of the fragments to raw bleeding bone. The coxa vara is overcorrected and the hip is placed in the valgus position. A Jewett nail is inserted which has been prebent to hold the hip in this position. The ends of the fragments are not anatomically reduced. The valgus position produces impaction at the lateral portion of the fracture site and reduces the shortening of the extremity; and, in the lateral plane, an offset the width of the cortex allows moderate overriding and better apposition of bone (Fig. 1). Cancellous bone is then packed about the anterior, posterior, and medial aspects of the fracture site, especially the latter. The cancellous bone may be autogenous or from the bone bank depending on the general condition of the patient and the available supply of suitable bone. When the internal fixation produces good stability, external support is not necessary. But if the surgeon is dubious about the fixation, the extremity is balanced in a Hodgen splint and moderate traction is employed for approximately 2 weeks. Case 1 illustrates this method.

In some fractures, because of comminution in the region of the greater trochanter, additional internal fixation is indicated, as illustrated in Case 2. Here, a "figure eight" wire loop was used, to secure better fixation of the loose trochanteric fragment and to prevent gaping at the fracture site when the leg was adducted.

Placing the hip in the valgus position is most important. This position produces an impacting force at the fracture site and transmits the weight in a more direct line. These factors are usually essential to promote union.

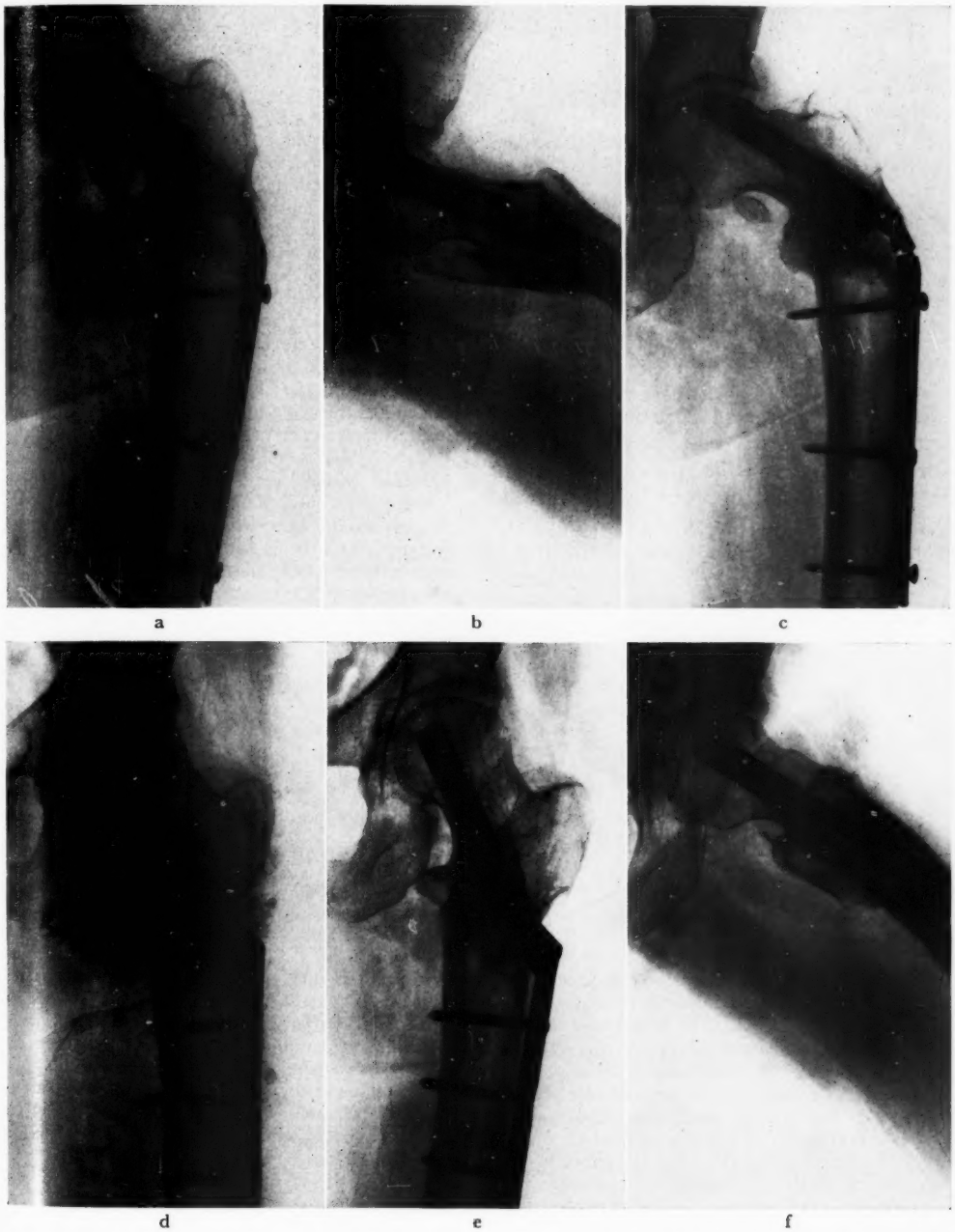


FIG. 2. a and b, Anteroposterior and lateral views showing a questionable nonunion; the nail-plate is intact; c, Nonunion is no longer in doubt; the nail-plate has broken. d, Appearance of the hip following operation. A Jewett nail has been inserted for internal fixation, and cancellous bone has been packed about the fracture site for osteogenesis. e and f, Anteroposterior and lateral views 11 months after operation showing union at the fracture site.

The valgus position may be produced as in Cases 1 and 2, or by an angulation osteotomy, as illustrated in Case 3.

The necessity of the valgus position of the hip is emphasized further by Case 4. This patient had 4 operations for the trochanteric fracture without obtaining union. One of these was an excellent operation as far as the bone grafting was concerned, but union was not obtained until the fifth operation, when the hip was placed in the valgus position. This is probably a record for optimism on the part of the patient, as she also had 2 operations on the forearm, 1 for nonunion.

Massive onlay bone grafts (single or dual) were used in 11 cases in this series, but they are not recommended as a primary method for internal fixation. The proximal fragment is usually too osteoporotic to permit the screws to hold well even with a dual graft (1), and the valgus position of the hip is difficult to maintain. When an onlay graft is used for these nonunions without additional metallic fixation, a body cast is required. This is a disadvantage in the age group in which many of these nonunions occur. The onlay graft may be used for added osteogenesis along with adequate metallic fixation.

ILLUSTRATIVE CASES

Case 1. Mrs. A. E., white, aged 58 years, was seen at the Campbell Clinic 18 months after she sustained a trochanteric fracture of the left hip, with a subtrochanteric element. At the time of fracture, her treatment had consisted of internal fixation with a Neufeld nail. Her postoperative course was uneventful. She began partial weight-bearing at 6 months. At 8 months, active physical therapy was used to increase motor power. Soon after this, she noted aching in the hip which she attributed to the exercise. The aching and pain persisted intermittently until 16 months after surgery. Routine x-ray examination showed possible nonunion.

When we first saw her, we believed that the nonunion was questionable, since the internal fixation was intact (Fig. 2a and b). She was allowed to continue weight-bearing with a cane. Twenty-two weeks later, the nail had broken and nonunion was no longer in doubt (Fig. 2c). There was 1¾ inches of shortening, with coxa vara.

At surgery the broken nail was removed. A fibrous union existed and the head and neck were in the varus position. The fibrous union and sclerotic bone were excised. The hip was placed in valgus position, with lateral and posterior cortices of the proximal fragment inserted into the medullary canal of the distal fragment (Fig. 1). A Jewett nail was inserted maintaining the valgus position of approximately 165 degrees. Fracture site was then packed with homogenous freeze-dried cancellous bone chips (Fig. 2d) and wound closed.

Postoperatively, the patient was placed in a balanced Hodgen splint in moderate abduction and neutral rotation. On the tenth postoperative day the Hodgen splint was removed, and she was up in a wheel chair. She was discharged from the hospital 3 weeks after the operation. Follow-up roentgenograms at 4 months showed beginning consolidation of the graft. Six months postoperatively she had essentially normal range of motion in the hip, she was walking with crutches, and bearing three-fourths of her weight. Eleven months after the operation the fracture was united and she could bear full weight on the hip and walk without support (Fig. 2e and f).

Case 2. Mrs. R. F., white, aged 55 years, was seen immediately following a comminuted trochanteric fracture (type 2) (2) of the right hip. The next day a reduction and fixation with a Jewett nail and 4 screws was performed (Fig. 3a). The patient's immediate postoperative course was uneventful. Three months postoperatively she was bearing half her weight with crutches. At 5 months there was penetration of the Jewett nail into the head, due to medial migration of the distal fragment. At 8 months, further penetration of the nail was noted, and the patient complained of early morning stiffness in the hip and also of aching pain after activity and at the end of the day. At 9 months the Jewett nail protruded through the head and impinged upon the acetabulum. At 1 year the nail protruded into the acetabulum. There was coxa vara and absorption of bone at the fracture and about the nail, indicating nonunion (Fig. 3b and c).

At operation, the Jewett nail was removed, the distal fragment was freshened, and a V-shaped defect was made in the cortex of the distal fragment. The proximal fragment was freshened, and the posterior and lateral cortices of the proximal fragment were fitted into the defect made in the distal fragment. A Jewett nail was inserted in a new position in the head and neck of the femur and attached to the shaft by 4 screws. The hip was placed in the valgus position, at approximately 165 degrees. A "figure eight" wire loop was passed through the attachment of the glutei to the greater trochanter and anchored beneath the plate to the proximal screw (Fig. 3d). Homogenous freeze-dried cancellous bone chips were packed about the fracture. The leg was placed in abduction in a Hodgen splint. The postoperative course was uneventful, and she was discharged from the hospital in 4 weeks.

Follow-up films revealed gradual consolidation of bone about the fracture site. Valgus position was maintained. Five months postoperatively she was bearing

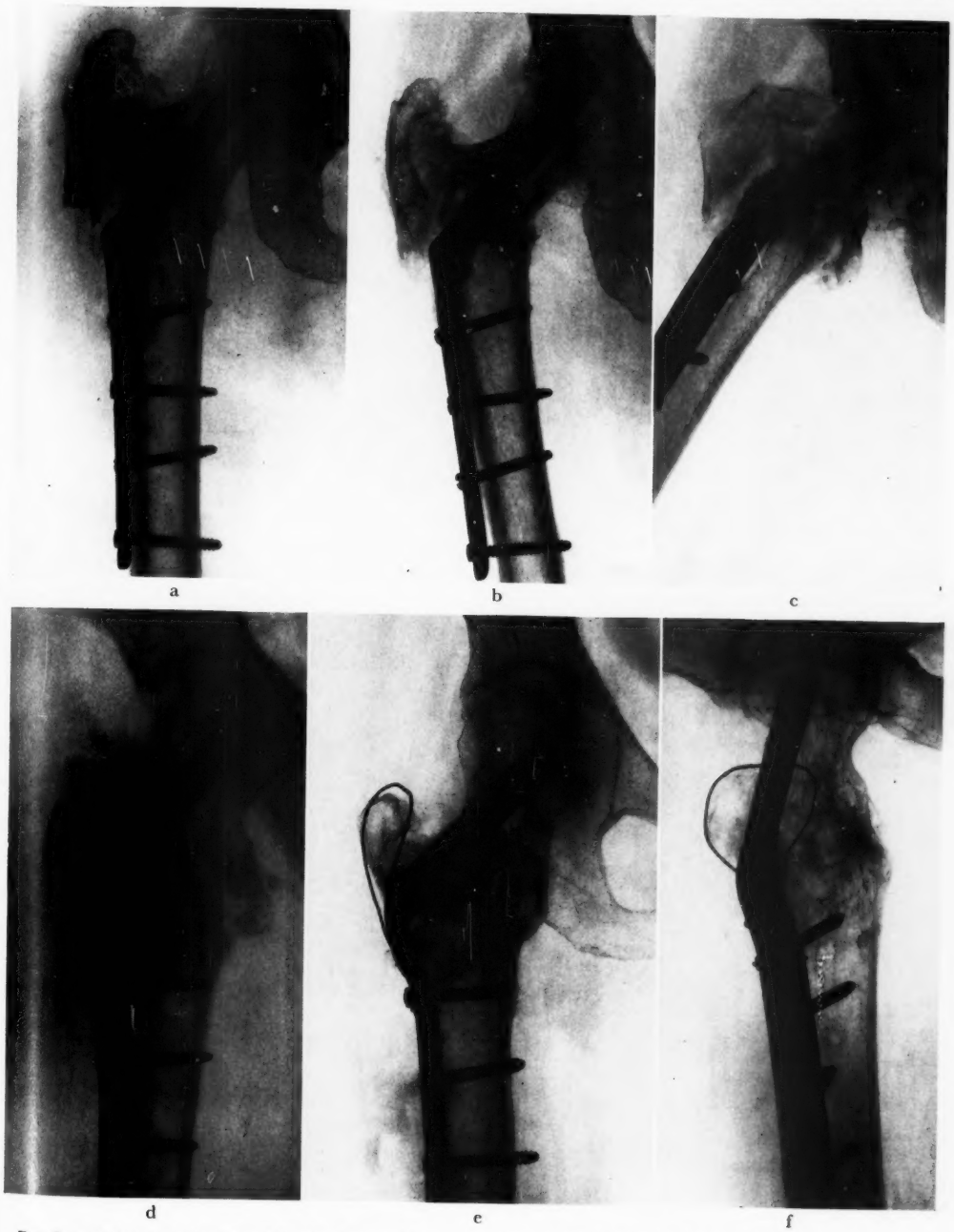
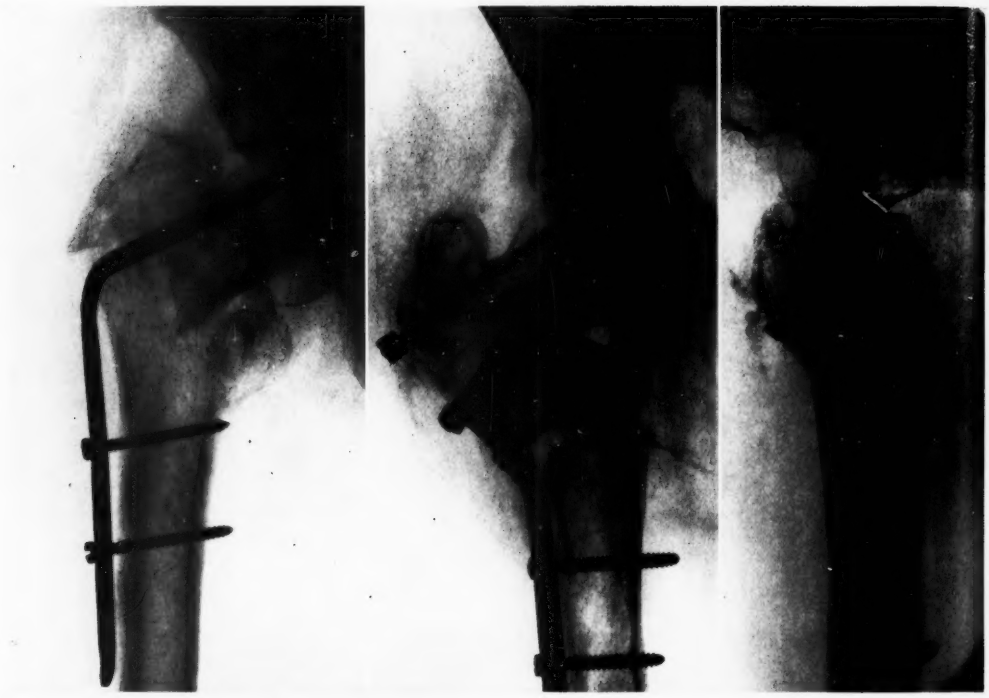


FIG. 3. a, Anteroposterior view following internal fixation for acute fracture. b and c, Anteroposterior and lateral views showing absorption of bone about the fracture site indicating nonunion. d, Anteroposterior view showing valgus position of hip after internal fixation with a Jewett nail and a "figure 8" wire loop. Cancellous bone has been packed about fracture site. e and f, Anteroposterior and lateral views showing bony union 1 year later.



a b c

d e

FIG. 4. a, Anteroposterior view showing nonunion of the fracture with coxa vara; b and c, Anteroposterior and lateral views 7 months following subtrochanteric osteotomy and internal fixation. d and e, Result 4 years later showing solid bony union. The internal fixation was removed 15 months after insertion.

one-half her weight with crutches, and at 1 year she had complete consolidation of the grafts with solid union (Fig. 3e and f).

CASE 3. Mrs. R. E. C., white, aged 61 years, was seen 3 months after an intertrochanteric fracture of the right hip. The day after the fracture, a Blount nail-plate had been inserted and a single spica cast applied. The spica cast was removed 4 weeks postoperatively, after which the patient experienced severe pain in the right hip, such that she was unable to sit erect. Because of continued pain she was referred to the Campbell Clinic. Examination revealed a 1¼ inch shortening of the right leg, and a complaint of pain upon any and all motions of the right hip. Roentgenograms revealed a coxa vara deformity of the right femur, with nonunion (Fig. 4a).

At surgery, the Blount nail-plate was removed, and a subtrochanteric osteotomy at the level of the lesser trochanter was performed. The head was brought into the valgus position and fixed with a prebent Jewett nail. Additional fixation was provided by 2 Knowles pins transfixing the fracture site (Fig. 4b and c). The patient's postoperative course was uneventful. At 5 months, motion in the hip was 75 per cent of normal or better in all directions except internal rotation, which was 25 per cent. The fracture progressed to solid union,

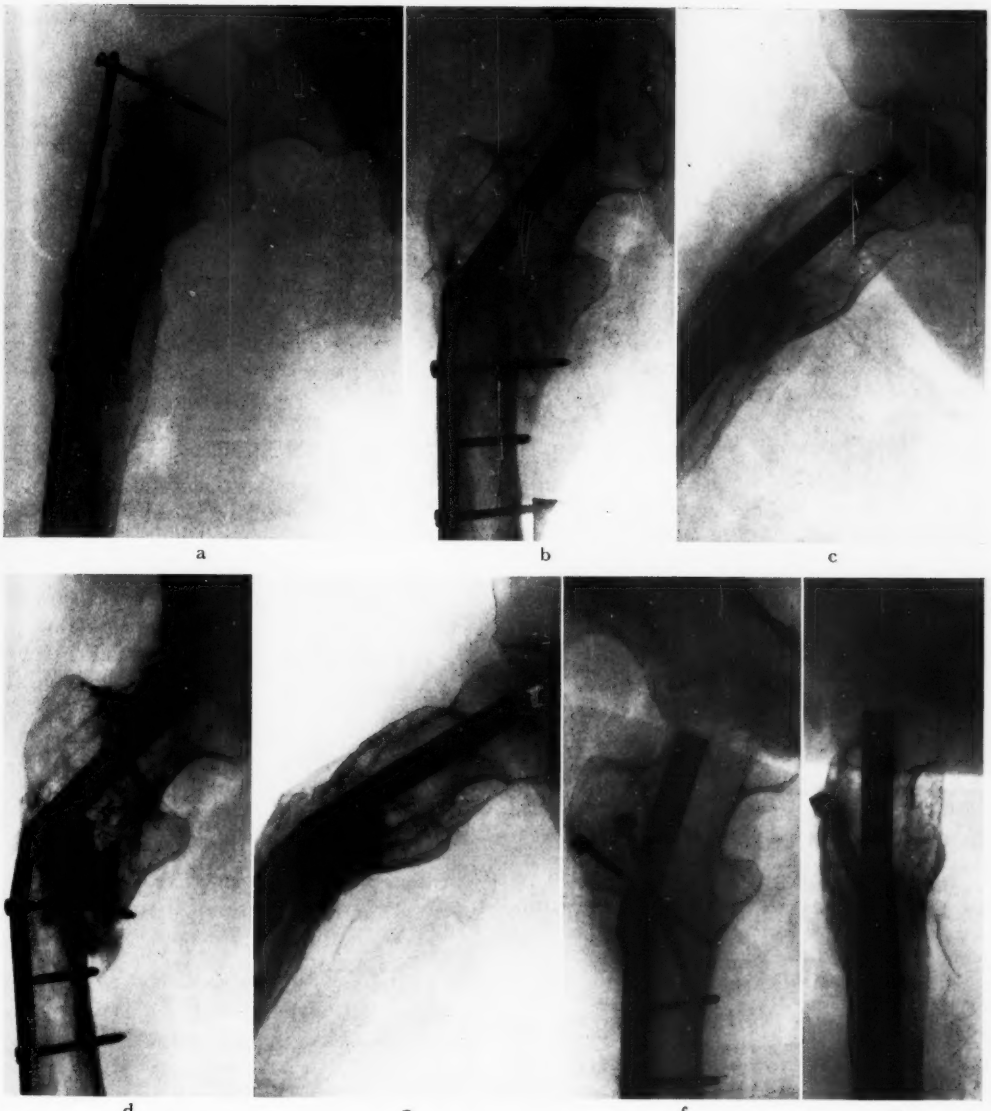


FIG. 5. a, Anteroposterior view showing condition of fragment when first seen. b and c, Nine months following fourth procedure, showing questionable early union. d and e, Twelve months after b and c. The nail and first screw have angulated and broken as a result of persistent nonunion. f and g, Anteroposterior and lateral views showing solid union 3½ years following last procedure for nonunion.

and the Jewett nail and Knowles pins were removed 15 months postoperatively. Follow-up at 52 months revealed normal range of motion except for internal rotation, which was 75 per cent of normal. Roentgenograms showed solid union (Fig. 4d and e).

CASE 4. Mrs. R. L. M., white, aged 31 years, sustained a subtrochanteric fracture in an automobile accident. After the immediate shock, skeletal traction was applied to the right femur. This was maintained for 8 weeks; it was followed by a spica body cast for 6

months and then a walking caliper brace. The fracture failed to unite. The initial procedure for nonunion was performed 2 years after the accident, and consisted of a bone graft and nail-plate followed by a spica cast. The type of graft is unknown. The patient returned to a brace 4 months later.

Four years after the accident, she was admitted to the Hospital for Crippled Adults (Memphis), with nonunion of the trochanteric fracture. Fifty-two months after the accident, the second bone graft was performed. The previous fixation (Fig. 5a) was removed, the bone ends were freshened, and a Neufeld nail was inserted. The proximal fragment was telescoped into the medullary cavity of the distal fragment. A cortical homogenous graft (frozen banked bone) was placed across the anterolateral aspect of the fracture and attached to the proximal and distal fragments with 4 screws. A spica and a half cast was applied. The fracture did not heal.

Five months later, the third surgical procedure was performed. At surgery it was found that the cortical graft had united to the proximal and distal fragments, but the graft was fractured at the site of nonunion. The Neufeld nail was removed, a second Neufeld nail inserted, and an autogenous iliac graft was cut into pencil strips and placed about the fracture site. The patient remained in the hospital at bed rest for 8 weeks after surgery, and continued bed rest at home. Three months postoperatively, she returned for physiotherapy and the fitting of an ischial weight-bearing brace. One year later she discontinued the use of the brace and resumed the use of crutches. Nonunion persisted.

Eighteen months after the third procedure, roentgenograms showed a nonunion, and fracture of the nail-plate. Six years and 4 months after the initial fracture, she again underwent surgery. At this time it was noted that the fracture site was sclerotic. The nail fragments were removed and the bone ends cut back to bleeding bone. A Jewett nail was inserted and cancellous autogenous iliac grafts were packed about the fracture site. A Hodgen splint was used postoperatively (Fig. 5b and c, taken 9 months postoperatively). Twenty-one months after the fourth procedure, roentgenograms revealed the Jewett nail broken as a result of nonunion (Fig. 5d and e).

The fifth surgical procedure was performed 8 years and 3 months (March 24, 1953) after the fracture. It consisted first of excising the eburnated bone ends, and placing the proximal fragment into marked valgus (170 degrees). The position was maintained by a prebent Jewett nail and 2 Knowles pins. Autogenous iliac grafts were placed about the fracture site. Postoperatively a spica and a half cast was applied for 3 months. Six months postoperatively the patient was walking with crutches bearing one-half weight. At 15 months she had discarded her crutches and was bearing full weight. She was last seen 3½ years after the last procedure and 11 years after the initial fracture: the fracture remained united, she walked without support, and was working full time (Fig. 5f and g).

CONCLUSIONS

1. Nonunion of trochanteric fractures is not as rare as indicated by the literature.
2. Trochanteric fractures associated with subtrochanteric fractures or with fractures of the base of the femoral neck are more prone to develop nonunion.
3. Nonunion is more prevalent in the younger age group.
4. The breaking of a nail-plate used for fixation of the acute fracture is usually due to the development of the nonunion rather than to inferior metal or faulty nail construction.
5. At operation, placing the hip in the valgus position is most important, thus straightening the weight-bearing alignment and producing an impacting force at the fracture site.
6. Moderate overriding of the bone cortices is preferable to anatomic reduction, in order to maintain better apposition.
7. Adequate internal fixation is necessary to maintain the valgus position of the hip.
8. After thorough denuding of the fragment ends to bleeding bone, copious quantities of bone chips should be packed about the fracture site, especially on the medial side. All bony crevices should be filled.
9. Onlay cortical grafts may be used in addition to metallic internal fixation, but alone they are not adequate for internal fixation.
10. With adequate internal fixation, body casts following surgery are not required.

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THE EFFICIENCY OF ESOPHAGEAL HIATAL HERNIA REPAIR

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THE DEFICIENCIES in our knowledge of esophageal physiology have become more apparent during the past decades as our medical literature concerning esophageal hiatal diaphragmatic hernia has increased. Serious scholars must question such basic concepts as the presence of an internal cardioesophageal sphincter, the intrinsic protective mechanism of the mucosa, and the modality of normal and abnormal motility as the result of numerous clinical reports.

We are indebted to a number of surgeons, but particularly Allison (1, 2), for focusing our attention on the significant pathologic effects of hiatal or sliding hernia in producing reflux esophagitis and its sequellae of fibrosis, stricture, and short esophagus. As the pathology of the lesion has been better understood, the need for a physiologic approach to its surgical correction has been obvious and imperative in order to achieve satisfactory results.

The clinical, roentgenologic, anatomic, and embryologic aspects of hiatal hernia have been adequately surveyed although there have been no reports of controlled series and many of the so-called follow-up reports have been sparse and incomplete. It was, therefore, our desire and aim to select a group of patients presenting the most difficult problem connected with hiatal hernia, that of ulcerative esophagitis, and to study carefully the effect of surgical correction of the hernia on the esophageal lesions.

From January 1952 to January 1956, 220 patients were seen in consultation for whom a roentgenologic diagnosis of esophageal hiatal hernia had been made. Twenty of these patients were considered primarily paraesophageal in type. Esophagoscopy was performed in 97 patients because of clinical symptoms suggestive of esophageal disease. An endoscopic diagnosis of ulcerative esophagitis was made in 46 instances, and biopsies were taken for histologic confirmation. We should like to point out that ulceration was considered mandatory for making a diagnosis of esophagitis because it was believed that the interpretation of other mucosal changes might be too variable for accurate evaluation.

Thirty of the 46 patients who had ulcerative esophagitis demonstrated were treated by transthoracic repair of the hernia. For the procedure, a left posterolateral incision was utilized and the pleural space was entered through the seventh intercostal space. The diaphragm was incised by a conforming semicircular incision about 2 inches from the hiatus (Fig. 1). The redundant tissues of the esophagodiaphragmatic ligament and associated peritoneum were excised and the ligament repaired or resutured below the diaphragm. The right crus was then reapproximated posteriorly and the diaphragmatic and chest wall wounds closed. Among the 16 remaining patients, 5 had resective operations for severe stenotic lesions and the other 11 were treated by endoscopic and medical methods, but they were all followed in a manner similar to the other patients. It is important to note that among the surgically treated patients 8 had recurrent hernias previously repaired at other institutions; 7 had had a repair by an abdominal approach and 1 by transthoracic exposure.

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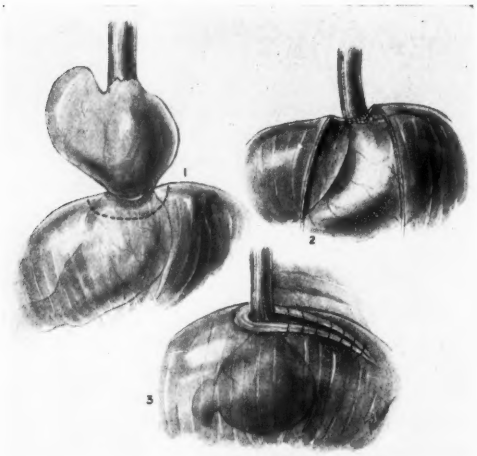

FIG. 1. Artist's diagrammatic representation of hiatal hernia repair. 1, Stomach herniating through hiatus with outline of diaphragmatic incision to be used. 2, Excision and reconstruction of esophagodiaphragmatic ligament. 3, Posterior approximation of the right crus, forming hiatal sling.

FIG. 2. Preoperative roentgenogram showing large hiatal hernia.

In all of the patients with esophagitis, repeat esophagoscopies were performed at 3 and 6 month intervals after diagnosis or surgical repair, and repeat biopsies were obtained. These patients were also examined roentgenologically for the presence of hernia and for cardiac sphincter competency. Among the group of patients with surgical reconstruction all except 2 demonstrated clearing of the esophagitis, and the endoscopic improvement was coincident with amelioration of the patient's symptoms. In 1 patient, hernia recurred postoperatively and the esophagitis persisted. A secondary repair, however, 9 months later resulted in clinical improvement and disappearance of the esophagitis. In 1 patient repair was carried out after a far-advanced stricture requiring dilatations had developed, and this patient has continued to need dilatations postoperatively although his general physical status has been markedly improved. There have been no operative deaths in this group of patients, and no significant complications have occurred. Except for the patient mentioned none of the patients have shown roentgenologic recurrence of the hernia in a complete follow-up of all from 6 months to 4½ years.

Of the 11 patients with esophagitis not treated by reconstruction or resection, 4 have died of causes not related to the esophageal disease. Three patients have shown marked progression of the lesion to stricture formation, and 4 have reported clinical improvement under medical management but none have demonstrated complete healing upon endoscopic examination.

In contrast to most of the previously reported series, the majority of our patients have been males. There were 8 females among the 46 patients exhibiting ulcerative lesions. The clinical picture they have presented, however, has been quite classical in that they have occurred most commonly in the sixth decade, and dysphagia, indigestion, substernal burning, epigastric pain, "heartburn," nausea, vomiting, and weakness constituted the primary presenting symptoms.

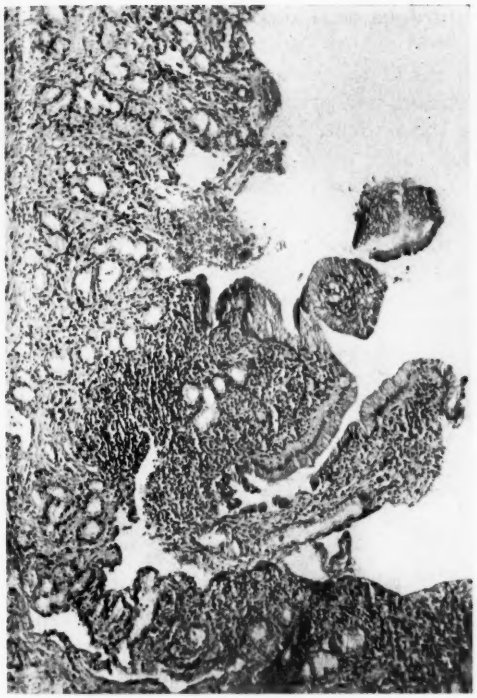

FIG. 3. Photomicrograph (×30) of peptic esophagitis showing ulceration of epithelium, infiltration of submucosa with inflammatory cells, and engorgement of vessels.

CASE REPORT

Illustrative of these patients are the following case reports.

CASE 1. E. J., a 55 year old white married male, was admitted on May 10, 1955 because of "food sticking in my throat" of about 4 years' duration. He stated that he was perfectly well until 4 years previously when the chief complaint had begun and was associated with regurgitation and substernal burning. For 3 months prior to admission, his symptoms had become most severe and were further complicated by frequent paroxysms of hiccoughs.

Physical examination showed a well developed, well nourished male in no acute distress. The blood pressure was 120/80, the pulse numbered 72, and respirations 16. No abnormalities were noted except for moderate venous varicosities of the left lower leg. A gastric analysis revealed 60 degrees of free hydrochloric acid, and roentgen examination of the chest and upper gastrointestinal tract showed a hiatal type of diaphragmatic hernia (Fig. 2).

FIG. 4. Oblique roentgenogram demonstrating large hiatal sliding hernia of stomach.

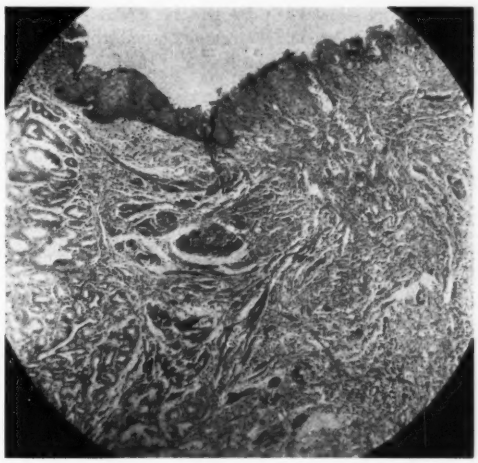

FIG. 5. Histologic section (×6) showing ulceration of epithelium above the cardioesophageal junction with submucosal inflammatory changes.

Esophagoscopy on May 10, 1955 after 9 days of medical regimen showed a severe ulcerative peptic esophagitis and stricture of lower esophagus, the former confirmed by biopsy (Fig. 3). Stricture was easily dilated to a size 45 F. with Hurst's dilators. On June 7, transthoracic repair of the hernia was done, and convalescence was uneventful. He was discharged June 24.

Repeat esophagoscopies on September 15 and December 12, 1955 demonstrated a normal esophagus to

visual examination and by histologic section. He has remained asymptomatic to the present time and roentgenologic studies have been normal.

CASE 2. B. F. F., a 64 year old white male chronic alcoholic, was admitted to the hospital on April 27, 1955 with the complaints of epigastric pain, substernal burning, and dysphagia of 4 years' duration. For the 6 weeks prior to admission he had noted severe exertional dyspnea, hematemesis, and tarry stools.

Examination showed an obese male in no acute distress. The blood pressure was 130/82, the pulse rate 96, and respirations were 20. The liver was felt 3 fingers below the right costal margin. The significant clinical findings were a hemoglobin of 9 grams and hematocrit of 33 per cent. Roentgenologic studies showed an apparent paraesophageal hiatal hernia (Fig. 4). Gastric analysis showed free hydrochloric acid of 27 degrees.

On May 4, 1955 esophagoscopy demonstrated an ulcerative esophagitis with evidence of a marked hiatal component of the hernia. Histologic examination of the mucosa confirmed the esophagitis (Fig. 5). After repeated transfusions and digitalization for heart failure, a transthoracic repair of the hernia was performed on June 30, 1955. Postoperative esophagoscopies on October 4 and December 6, 1955 revealed a normal esophagus. The hemogram has remained normal, and the patient has no gastrointestinal complaints.

SUMMARY

We do not presume to have answered any of the questions previously enumerated regarding basic esophageal physiology by this study. We believe, however, that the patients described demonstrate the efficiency of a physiologic approach in reconstruction of the normal hiatus for correction of hiatal hernia. If the repair is performed before irreversible pathologic changes have taken place, the stomach returned to the abdomen, and the cardiac sphincter "replaced" by posterior approximation of the right crus, then a satisfactory herniorrhaphy has been accomplished and good clinical results may be expected in the majority of cases. It is also our opinion that the clearing of ulcerative esophagitis following surgery is adequate basis for these deductions and probably of equal or greater value than roentgen evidence of hernial reduction and cardioesophageal sphincter competency in the evaluation of postoperative results.

There has been considerable attention paid in the past to such technical details as suture material, displacement of the hiatus, gastric acidity, the approach, whether abdominal or thoracic, phrenic nerve interruption, and preoperative weight reduction of the patient. It has been our impression that these are not the important factors in securing good results but rather secondary features which may be of value for individual patients. We have not used phrenic nerve interruption on any of the patients reported. We strongly advise leaving the muscular hiatal sling intact. Cotton or silk suture material has been used exclusively. Although we have utilized a thoracic approach in our patients, we believe that an abdominal exposure would be just as satisfactory if the criteria established for adequate repair can be satisfactorily met by the latter route.

CONCLUSIONS

1. A group of 220 patients with roentgen evidence of esophageal hiatal diaphragmatic hernia were seen in a 4 year period. Esophagoscopy was done on 97 because of symptoms suggesting esophageal disease.

2. Forty-six patients had ulcerative esophagitis. None of 11 treated by endoscopic and medical means have shown complete inactivity or healing by repeat esophagoscopy.

3. All except 2 of the 30 patients with ulcerative esophagitis treated by transthoracic repair of the hiatal hernia have shown complete clearing of the esophagitis. A return of the hernia occurred in 1 patient which was later successfully repaired with clearing of the esophagitis. A far-advanced stricture has complicated the course of 1 patient.

4. A physiologically sound method of hiatal hernia repair has been described which has proved efficient in the treatment of esophageal hiatal diaphragmatic hernia.

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CONGENITAL ATRESIA OF THE ESOPHAGUS WITH TRACHEO-ESOPHAGEAL FISTULA

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IT IS 14 YEARS since Haight first successfully operated upon a case of atresia of the esophagus with tracheo-esophageal fistula. Although much has been learned during this time about operative technique and postoperative care, the over-all mortality still is high. In 1946 we operated upon 4 infants with this deformity and had a mortality of 100 per cent; in 1954 the mortality in 13 operations was 23.0 per cent; in 1955 we operated upon 9 infants with 1 death, or a mortality of 11.1 per cent. Our average mortality in 113 patients surviving operation during the past 10 years is 50.4 per cent.

From an analysis of our mortality statistics, we were surprised to find that 77 per cent of the deaths were due to pulmonary complications. Most infants upon admission had atelectasis, pneumonitis, or bronchitis, or all three. These infections were made worse by anesthesia and the trauma of operation. In a few instances they were accentuated by a leaking anastomosis and, we can only conjecture, that in some instances they were the cause of a leaking anastomosis. A considerable number of fatal pulmonary complications were the result of aspiration of formula during the early postoperative period.

The second most frequent cause of death following operation was the presence of other congenital defects. Some were recognizable and corrected surgically with rather high mortality; others were found at postmortem examination. It was often difficult to decide whether the second congenital deformity was the primary cause of death, or whether it was a contributory cause in a child weakened by pulmonary infection and operation.

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Cardiovascular defects head the list of associated anomalies, 11 cases or 9.6 per cent. Renal and gastrointestinal anomalies (atresia) follow, each with 7 cases or 6.2 per cent. Other associated anomalies varied in severity and number: one child had simply an extra digit on one hand; another had a Klippel-Feil syndrome, bilateral hydroureters, atresia of the rectum, and bilateral clubfeet.

Associated defects represent an uncontrollable factor in the mortality following operative closure of tracheo-esophageal fistula and re-establishment of continuity of the esophagus. Our attention, therefore, has been directed toward prevention of deaths from pulmonary complications. Our purpose in this paper is to review the changes in preoperative, operative, and postoperative treatment which in a measure account for our recently lowered mortality.

MATERIAL

During the past 10 years 117 patients with atresia of the esophagus have been admitted to the Children's Memorial Hospital. Three infants were not operated upon because they were moribund upon admission. One child died on the operating table during the surgical procedure. The remaining 113 cases form the basis of this report.

The weights of these infants varied from 3 pounds to 9 pounds 1 ounce. There were 43, or 38 per cent, whose weight was 5 pounds or less. The birth weight of infants with atresia of the esophagus averages about 1 pound below average.

The age of these children upon admission ranged from less than 24 hours—in rare instances—to 13 days. It seems incredible but by virtue of good fortune the 13 day old infant survived operation and is well. The

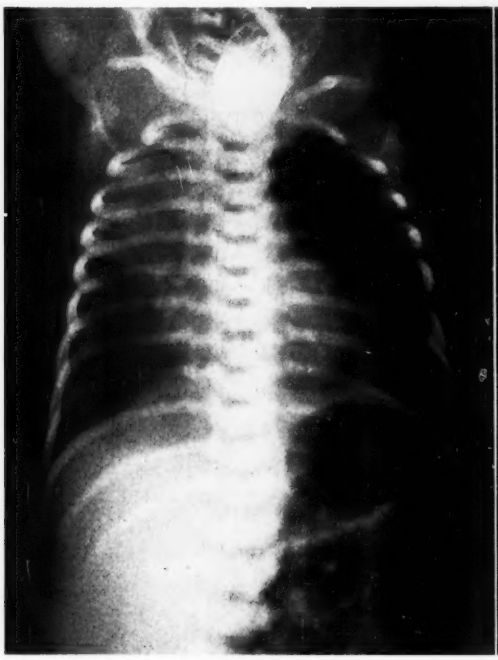

FIG. 1.

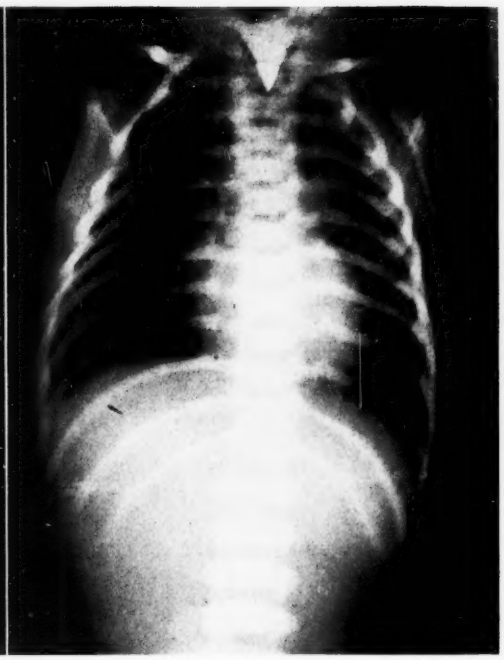

FIG. 2.

FIG. 1. Contrast media outlining the upper end of the esophagus and air in the gastrointestinal tract are diagnostic of atresia of the esophagus with tracheo-esophageal fistula. Atelectasis of the right upper lobe is often present.

FIG. 2. A blind esophageal pouch with no air in the gastrointestinal tract is typical of uncomplicated atresia of the esophagus.

average age upon admission was 3 days. Of all admissions 68.5 per cent were less than 4 days old and 31.5 per cent were more than 4 days old.

TYPE OF DEFORMITY

Congenital atresia of the esophagus with associated fistula were distributed as follows according to the classification of Vogt: type I—absence of esophagus—none; type II—atresia of esophagus without fistula—6 cases; type III—atresia of esophagus with tracheo-esophageal fistula (a) fistula between upper segment of esophagus and trachea, none; (b) fistula between lower segment of esophagus and trachea, 107 cases; and (c) fistula between both segments of esophagus and trachea, 4 cases, including 1 case of tracheo-esophageal fistula without atresia of the esophagus (successfully repaired); for a total of 117 cases.

DIAGNOSIS

Early diagnosis, one of the controllable factors which can lower the mortality tremendously, is not difficult to make and is missed by the obstetrician or attending physician only because of its rarity. The history is rather characteristic. Immediately after birth, the infant chokes and coughs because of an excessive amount of secretion in its nostrils and mouth. Prolonged aspirations are often necessary to establish normal breathing. If the diagnosis is not suspected in the delivery room it can be made by an experienced nurse when the first feeding causes immediate coughing, choking, and prompt regurgitation of all fluid.

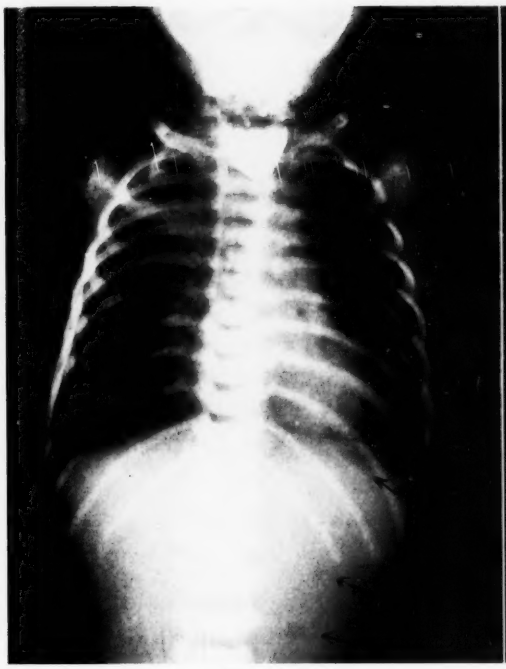

FIG. 3.

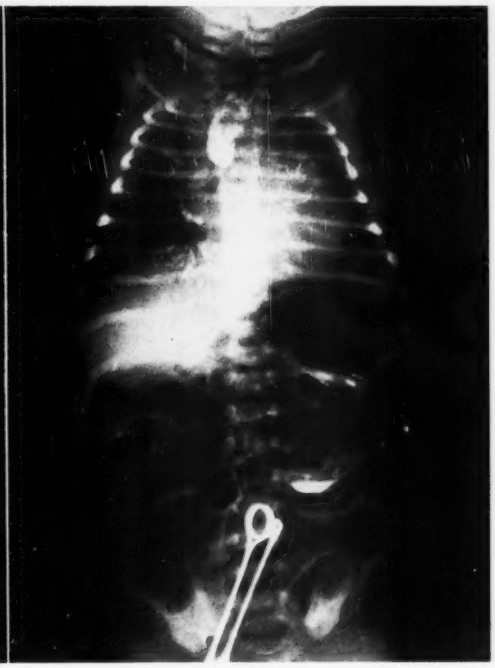

FIG. 4.

FIG. 3. A few bubbles of air in the gastrointestinal tract (easily missed) means a small tracheo-esophageal fistula.

FIG. 4. Distention of the gastrointestinal tract with air indicates a large fistula. Some oil has been aspirated and gone through the fistula into the stomach and bowel.

Insertion of a catheter into the esophagus and demonstration of persistent obstruction strongly suggests a positive diagnosis. However, the catheter if very soft may curl up in the dilated upper end of the esophagus and seem to enter the stomach. A diagnosis may also be missed because of this unusual occurrence. A catheter was introduced supposedly into the esophagus and went directly into the stomach. Later it was found that the catheter had entered the trachea, slid through the tracheo-esophageal fistula and entered the stomach.

Fluoroscopic and roentgen examination are necessary to confirm the diagnosis. While holding the infant in the upright position, anteroposterior and lateral x-ray films are made to demonstrate pulmonary disease, to show the presence or absence of air in the gastrointestinal tract, and to detect the presence of other anomalies—especially atresia of the bowel. Then the child is placed prone on the fluoroscopic table and a small catheter is inserted through the mouth or a nostril into the posterior pharynx and under fluoroscopic control is extended into the upper end of the esophagus. A small amount of lipiodol (1 to 2 c.c.) is injected and watched as it goes directly into the stomach or fills the esophageal pouch proving the presence of atresia of the esophagus. Spot films are made as a matter of record. Immediately after the films have been exposed the lipiodol is aspirated from the esophagus.

Filling of the blind pouch of the esophagus and the presence of air in the gastrointestinal tract as determined from the original film confirm the diagnosis of atresia of the esophagus with tracheo-esophageal fistula (Fig. 1). Complete absence of air in the gas-

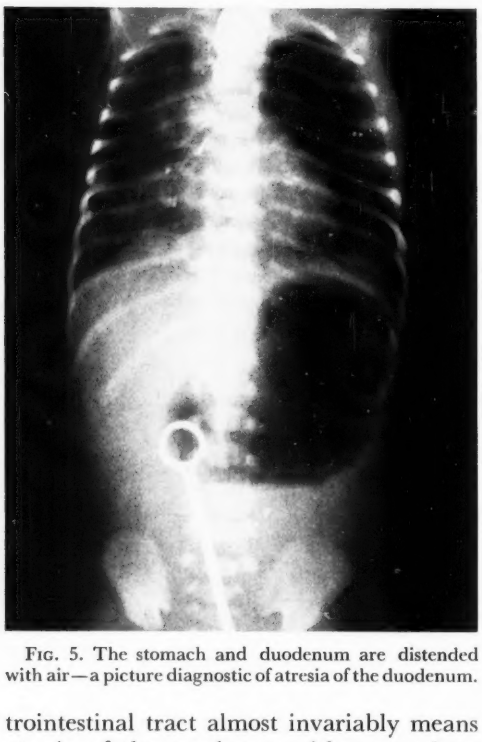

FIG. 5. The stomach and duodenum are distended with air—a picture diagnostic of atresia of the duodenum.

trointestinal tract almost invariably means atresia of the esophagus without tracheoesophageal fistula (Fig. 2). It is well to bear in mind that the size of the fistula varies greatly. If it is small only a few bubbles of air in the stomach and bowel will be seen (Fig. 3). If the fistula is large the stomach and bowel will be markedly distended with air (Fig. 4). In fact, the distention may be so great as to interfere with respiration and make prompt operation imperative.

While focusing attention on the disease in the esophagus and lungs it is well not to forget the abdominal findings. The presence of fluid levels means associated atresia of the bowel. In our first case of such combined anomalies we overlooked the obvious diagnostic finding of atresia of the duodenum (Fig. 5).

Written and mental notes are made of the extent of atelectasis or pneumonia. The degree of pulmonary involvement influences the prognosis and this fact is routinely discussed with the parents or the grandparents before the operation is performed. The shock of a postoperative mortality is softened if relatives are apprised of the gravity of the operation itself and the inescapable dangers of giving a baby with pneumonia an anesthetic.

PREOPERATIVE CARE

The child is placed in an isolette in an atmosphere of approximately 30 per cent oxygen and saturation humidity. Needless to say, a complete physical examination is made with attentive search for other congenital anomalies. Proper amounts of saline and glucose are given according to the age of the child and its state of dehydration. Preoperative blood transfusions are used as indicated.

If the child's lungs are clear (rare), operation should be performed as an emergency, as soon as it is possible to get matched blood from the bank and prepare the operating room. It is a foregone conclusion that soon the lungs will be involved. If, as usual, atelectasis is already present it is usually in order to spend a few hours in clearing the esophagus and trachea. Sometimes such treatment improves the pulmonary condition; rarely does it become worse under treatment. Suction of the pharynx stimulates cough which occasionally releases a plug of mucus from a bronchus. Some years ago for a time we employed continuous suction through a catheter placed in the upper end of the esophagus. We reasoned that continuous suction would avoid the trauma of repeated catheter insertions. We were wrong. It proved difficult in a constantly wiggling infant to keep the catheter in the correct position. The thick, tenacious saliva required suction so strong that the mucosa was often drawn into the catheter. In 1 instance negative pressure on the mucosa caused considerable bleeding and completely defeated our purpose. Intermittent suction every 15 minutes with a catheter as described later under postoperative care is now routine. One is amazed at the amount of secretion which constantly accumulates in the esophagus and posterior pharynx.

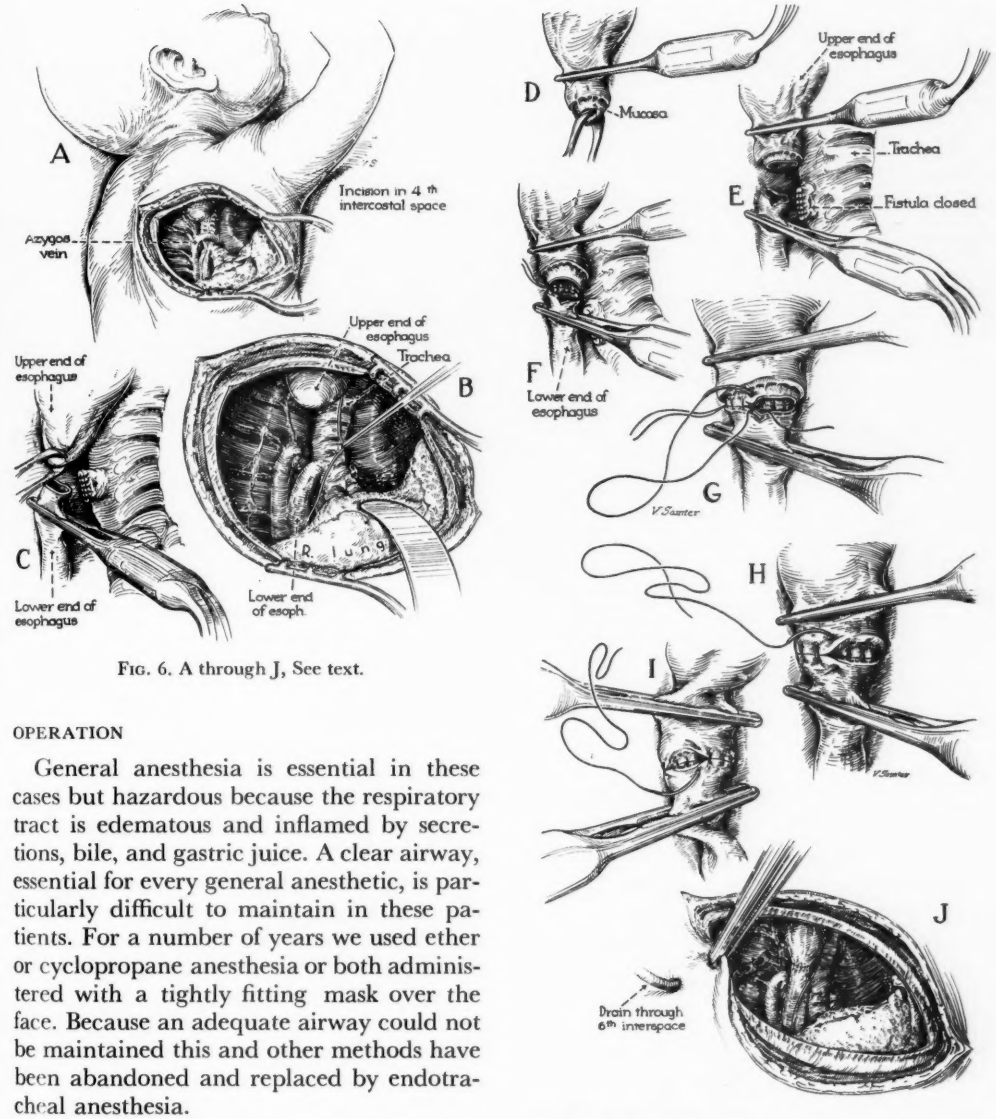

FIG. 6. A through J, See text.

OPERATION

General anesthesia is essential in these cases but hazardous because the respiratory tract is edematous and inflamed by secretions, bile, and gastric juice. A clear airway, essential for every general anesthetic, is particularly difficult to maintain in these patients. For a number of years we used ether or cyclopropane anesthesia or both administered with a tightly fitting mask over the face. Because an adequate airway could not be maintained this and other methods have been abandoned and replaced by endotracheal anesthesia.

Anesthesia is induced by open drop ether. Induction will necessarily be slow because exchange of gases is small in these weak, underweight, and sick infants. Induction must be cautious to avoid spasm or increased secretions which will completely occlude the air passages. After the child is asleep an endotracheal tube is inserted. Through this tube the anesthetist is now able with a polyethylene tube to aspirate the tracheobronchial tree. If frequent aspirations are necessary it will be difficult to maintain satisfactory levels of anesthesia. Positive pressure anesthesia may be used to inflate the atelectatic lung but must be used with caution or the stomach will become overinflated by air escaping through the tracheo-esophageal communication.

FIG. 7. A Sampson aspirator which is marked with adhesive tape to avoid trauma to the anastomosis.

The child is placed on its left side but inclined forward so that its right posterolateral surface faces the operator (Fig. 6A). The right arm is suspended from the anesthetic shield.

A posterolateral, periscapular incision is made and the chest entered through the fourth intercostal space. A thyroid retractor serves well to elevate the scapula, and the ribs are spread with a mastoid retractor. Employing the transpleural approach the fistula can be occluded within 20 to 30 minutes from the time the skin incision has been made. It is advantageous to do this part of the operation rather rapidly because the anesthetist will find it difficult to control the respiratory exchange until the fistula is closed. The extrapleural approach as previously advised (2) is more time-consuming and is often difficult to accomplish without making a small opening into the pleura, especially when dissecting around the azygos vein and its branches. Another advantage of the transpleural approach is that the right lung can be collapsed, the aspirated secretions can be expressed into the bronchus and trachea and be suctioned out by the anesthetist. A third advantage of the transpleural approach is that after the anastomosis is completed, the previously atelectatic lung, usually the right upper lobe, can be re-expanded with mild positive pressure under direct vision. Mention must be made of the disadvantage of the transpleural approach. If a leak occurs in the anastomosis of the esophagus, empyema is likely to develop and be fatal. However, to date we have been spared this complication.

After the chest is opened the azygos vein is identified, doubly ligated and cut (Fig. 6B). Immediately beneath the divided azygos vein the vagus nerve is seen and serves as a guide to the distal esophagus. The distal segment of the esophagus is freed at its attachment with the trachea or bronchus. The tracheo-esophageal fistula is closed with a suture ligature of No. 3-0 silk or with fine interrupted silk sutures as the surgeon prefers (Fig. 6C). It will be found that control of anesthesia is simplified immediately after closure of the fistula. The distal segment of the esophagus is dissected only as far downward toward the diaphragm as necessary to obtain sufficient length for anastomosis.

The proximal end of the esophagus is easily identified lying posterior to the trachea at the apex of the pleural space. The distal portion of this esophageal pouch is adherent to the trachea and must be freed from it with precise, sharp dissection. Blunt dissection at this point will result in tearing either the esophagus or trachea. After it has been separated from the trachea, the remainder is freed by blunt dissection as far as the posterior pharynx. Usually adequate length necessary for the anastomosis is better obtained by maximum freeing of the proximal portion of the esophagus and minimal freeing of the distal portion. Mobilization of the distal esophagus must be done with the realization that good blood supply is as im-

portant for a satisfactory anastomosis as length. We have been able to accomplish an end-to-end anastomosis in every case of atresia with a tracheo-esophageal fistula. After the esophagus is freed, the distal portion is clamped with a Potts ductus clamp and transected just distal to the suture ligature. The proximal end is similarly clamped and the muscular layer cut from its tip. The intact mucosal layer is then pulled downward with an atraumatic tissue forceps while the ductus clamp is partially released (Fig. 6D). By cutting the mucosal layer distal to the muscular layer identification during anastomosis is aided. Many times the lumen of the proximal end of the distal esophagus is very small. Increased diameter can be obtained by making a small longitudinal slit in the wall of the esophagus (Fig. 6E). A 1 millimeter longitudinal incision adds 2 millimeters to the circumference at the site of the anastomosis. The anastomosis is accomplished by use of two layers of interruped No. 6-0 silk in the following manner: The ends of the esophagus held by the clamps are approximated and maintained in that position by an assistant. No tension is allowed on the suture line until the anastomosis is completed. First, the posterior (farthest away from the surgeon) mucosal edges of the two ends of the esophagus are sutured (Fig. 6F). The knots are placed *inside* the lumen of the esophagus. We believe better healing follows if the knots are inside the lumen rather than buried between the layers of the esophagus. Then the anterior edges of the mucosal layer are sutured, again in such a fashion that the knots are inside the lumen (Fig. 6G). The muscular and serosal surfaces (nearest the surgeon) are then coapted with No. 6-0 interrupted silk sutures (Fig. 6H). The clamps are elevated and the posterior surfaces of muscularis and serosa are sutured (Fig. 6I). From 8 to 12 individual sutures, depending upon the size of the esophagus, are necessary for closure of each layer. Leaks at the anastomotic site have been less of a problem since we adopted the two layer end-to-end suture rather than the overlapping sleeve type of suture. In fact, during the past 4 years we have not had a detectable leak of an anastomosis. Time will mar that record.

The pleural space is drained by using an ordinary No. 12 French catheter from which the tip has been cut and into which a number of extra holes have been made (Fig. 6J). The catheter is drawn through a stab wound two ribs below the incision and it is anchored to the inside of the chest wall with a fine surgical gut stitch around the tip. The stab wound in the skin must be tiny so that the catheter fits snugly enough to prevent aspiration of air into the chest. The end of the catheter is brought near to, but not against, the anastomosis. The lung is expanded completely and the ribs are approximated with 1 heavy surgical gut suture. The intercostal bundle is closed with a continuous suture of surgical gut. The muscles are closed in layers and the skin with silk. The thoracotomy tube is clamped after the anesthetist has re-expanded the lung completely. As soon as the infant is brought to the recovery room the drainage catheter is attached to a water seal bottle.

POSTOPERATIVE CARE

The postoperative care of these infants is entrusted to residents and nurses who are thoroughly acquainted with the details. The most important part of the postoperative care, often difficult to obtain, is a well trained nursing staff. With each change of nurses, there must be 1 nurse in each shift who thoroughly understands the problem and can direct her associates. All these children are placed in 1 ward under constant supervision. Since most of the postoperative deaths are due to respiratory complications, the real problem is to avoid the 3 major complications—atelectasis, pneumonitis, and aspirations of feedings.

Practically all of these infants have scattered rales throughout both lung fields before operation and following operation this condition is accentuated. A newborn infant has a very poor cough reflex and the weak, underweight infant who has just been oper-

ated upon has none. The only way to clear the tracheobronchial tree, therefore, is to stimulate the infant to cry and as it cries to aspirate the material from the posterior pharynx. The nurses must be instructed to repeat this maneuver every hour. Not only are they instructed to do this but they must be shown how it is done. An ordinary No. 12 French catheter is used as the suction tube. A French catheter is preferred to a tracheal catheter because it is almost impossible to suction blindly the pharynx of a baby with a tracheal catheter and not have the uvula sucked onto the open end of the catheter. If the opening of the French catheter is placed so that it faces the tongue, the blind tip of a catheter merely pushes the uvula aside and suction is applied at the base of the tongue and posterior pharynx instead of to the uvula or soft palate. The amount of suction as well as the time of suction must be controlled. The most efficient way is to have the catheter attached to a Sampson aspirator (Fig. 7). By placing the thumb over the escape hole, suction can be applied as desired. The distance from the lips of the baby to its posterior pharynx is measured, and this distance is marked on the catheter with a strip of adhesive tape to prevent the catheter from being inserted too far and endangering the anastomosis.

Antibiotics are used to supplement good nursing care. Practically all antibiotics have been used, alone and in various combinations. We now routinely use a combination of penicillin, 150,000 units, and dihydrostreptomycin, .25 gram, given intramuscularly twice a day. Antibiotics given intravenously are apt to cause thrombophlebitis and by so doing make parenteral feeding a problem.

We are firm believers in the value of humidity as a solvent in the treatment of pneumonitis and bronchitis. The infant is routinely placed in a heated isolette or incubator flooded with oxygen and saturation humidity. If there is much congestion in the chest and the secretions are very tenacious, a mucolytic such as alevaire is added to the humidity. The infant is kept in this humid atmosphere for at least 3 days depending upon its progress.

Intravenous fluids supplemented with vitamins, especially vitamin C, are given daily. The amount of fluid is calculated to supply the infant with approximately 40 cubic centimeters per pound per day. Physiologic saline solution is not given if the infant is less than 48 hours old. On and after the third day of life sufficient physiologic salt solution is given to provide .25 to .5 gram of sodium chloride each day.

The child is given nothing by mouth before the fifth postoperative day. At this time under fluoroscopic control a lipiodol swallow is given. If the anastomosis is patent and there is no evidence of a leak, the child is started on oral feedings. The first several feedings are glucose water and, if all goes well, small amounts of a formula of condensed milk 1:8 dilution follow.

When oral feedings are begun the second major nursing problem is encountered. Each group of nurses is instructed that the child *must be fed slowly*. It is explained to the nurse that the reason the baby must be fed slowly is that the esophagus is still patterned like a funnel and fluid just will not go down rapidly. It is not a question of the baby not being able to swallow, but rather that of a narrow anastomotic channel which will not pass the milk as fast as the hungry baby will take it. A simple diagram will often clarify the problem. The proximal esophagus, still very dilated, becomes filled and then overflows. If the baby is fed rapidly while lying on its back the feeding will fill up the back of the throat and the child will drown in its own formula.

The nurse is instructed to hold the baby on her lap in the normal nursing position and feed with an eyedropper. The eyedropper allows only a small swallow and while it is being refilled the swallowed formula has time to go through the narrowed esophagus into the stomach. A connected aspirating machine is at the nurse's side in case the baby regurgitates. After the feeding the child

is placed on either side but never is it allowed to lie on its back. The feedings are usually restricted to ¼ ounce every 3 hours for 24 hours. If no difficulties have been encountered, the feedings are increased to ½ ounce and later up to an ounce. The natural impulse to increase the formula too rapidly for these puny, underweight infants must be curbed. In fact, the formula is increased very slowly to avoid vomiting and its often fatal consequences.

A gastrostomy is done with reluctance and only under the following circumstances: (1) The infant who is admitted at about age 1 week requires a gastrostomy for feeding purposes. Ordinarily, a newborn infant gets along well without food the first 10 days of life. At about this time the infant, especially one hampered by underweight and pulmonary infection, goes into a sudden decline and fades out of the picture. If the anastomosis, therefore, is not done until the sixth or seventh day after birth, a gastrostomy is done and small frequent feedings are given. (2) The premature or small infant weighing 3 to 4 pounds requires a gastrostomy for the simple reason that it is not strong enough after operation to take sufficient food for adequate nourishment. (3) If the anastomosis leaks a gastrostomy will be necessary for feeding and will later simplify dilatation of the stricture which inevitably develops.

It seems so reasonable to assume that a gastrostomy would be a great aid after correction of atresia of the esophagus with tracheo-esophageal fistula. Actually, gastrostomies are the source of much trouble. Unless feedings are given by very slow drip and in small quantities they are regurgitated through the relaxed cardia. A gastrostomy by no means eliminates the danger of vomiting and aspiration. For some unknown reason food will not readily pass through an infant's stomach with a gastrostomy tube in it. Infection about the gastrostomy wound and loss of stomach contents are a source of much annoyance. Bleeding from a gastrostomy wound may occur. In this series gastrostomy was done in 17 cases, or 15.8 per cent. Very few have been done during the past 4 years.

ATRESIA OF THE ESOPHAGUS WITHOUT TRACHEO-ESOPHAGEAL FISTULA

This article does not include a detailed discussion of this deformity. It is our policy to explore all such patients with the hope of reconstructing the esophagus. In 1 of the 6 patients in this group, incidentally, a Mongolian idiot, an end-to-end anastomosis was accomplished but the child died of unrelated complications. In another case no air in the gastrointestinal tract suggested atresia of the esophagus without fistula. At operation a tiny fistula was found and an end-to-end anastomosis of the esophagus accomplished.

If an end-to-end anastomosis cannot be done—inadequacy of the distal segment usually precludes it—the upper end of the esophagus is brought out above the left clavicle. If the child is in good condition a gastrostomy is performed at once, if not, the gastrostomy is performed a couple of days later.

We have in 1 instance, previously reported, transplanted the stomach into the left chest and attached the proximal end of the esophagus to the fundus of the stomach. In another child the jejunum, prepared by a Roux-Y procedure, was successfully transplanted behind the sternum and attached to the upper end of the esophagus. Attempts to construct an esophagus from the jejunum or the ascending colon, we believe, should be deferred until the child is at least 18 months old. Three children are awaiting construction of an esophagus.

DISCUSSION

In the field of pediatric surgery no condition is more demanding than that of atresia of the esophagus with tracheo-esophageal fistula. During the preoperative period the infant needs constant attendance. The operation demands the utmost gentleness in handling structures of wet tissue paper consistency. The postoperative care is a matter of 24 hour attendance to details by the at-

tending, resident, and nursing staffs. In spite of all this work many of the infants still die.

During the past 10 years much has been learned about the care of these infants. In retrospect it seems we should have learned much faster. Uncontrollable and controllable factors determine the percentage of mortality. The uncontrollable factors are multiple congenital anomalies and the accidents which are bound to occur in the treatment of this serious deformity. The controllable factor, and one which will eliminate many of these pulmonary complications, is early diagnosis. Statistics would be far different if all these children were operated upon during the first 12 hours of life.

If in delivery rooms there were large signs which read:

THE NEWBORN INFANT WHO CHOKES AND BREATHES POORLY, WHOSE NOSE AND MOUTH ARE FILLED WITH EXCESSIVE SECRETIONS HAS ATRESIA OF THE ESOPHAGUS UNTIL PROVED OTHERWISE.

and if in the newborn nurseries there were signs which read:

THE INFANT WHO ALWAYS COUGHS AND REGURGITATES IMMEDIATELY WHEN FED HAS ATRESIA OF THE ESOPHAGUS.

the mortality would drop precipitously. It is not difficult to imagine the walls of delivery and nursery rooms heavily placarded by zealous groups interested in their particular phases of newborn problems.

CONCLUSIONS

The surgical treatment of atresia of the esophagus with tracheo-esophageal fistula has been more successful since we have focused attention upon the following items: (1) persistent and methodical preoperative removal of secretions from the nose and throat; (2) endotracheal anesthesia; (3) transpleural operation; (4) two layer suture anastomosis of the esophagus with No. 6-0 silk; (5) instruction to residents and nurses on the importance of maintaining a clear airway and of slow postoperative feeding with a medicine dropper; and (6) early diagnosis to reduce the mortality further.

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MODERN TRENDS IN THE MANAGEMENT OF FACE AND BROW PRESENTATIONS

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IN RECENT YEARS, our results in the management of face and brow presentations have greatly improved. In order to analyze the reasons for this improvement we have reviewed all cases on the Obstetrics Service of the Harlem Hospital, New York, from July 1, 1942 to June 30, 1956. One hundred and two face and 23 brow presentations have been managed in this period. A previous paper from this institution (7) presented data on 87 face and 13 brow presentations observed from January 1, 1914 to June 30, 1942.

There were 50,345 deliveries during the 14 year period of the present study. The incidence of face presentations was 1 in 494, of brow presentations 1 in 2,189.

ETIOLOGIC FACTORS

There were 40 primiparas, 75 multiparas, and 10 grand multiparas. We consider as a grand multipara a patient who has had 5 or more previous viable pregnancies. These proportions are about the same as for all admissions to the Obstetrics Service. Seventeen per cent of the patients with brow presentations were grand multiparas, about twice the normal incidence.

In 39 patients x-ray pelvimetry was done. Sixteen or 41 per cent of these had a true conjugate of less than 10.5 centimeters. According to the method of Snow, which we use, this measurement represents a contracted pelvis.

There were 2 cases of fibroids associated with face presentation.

There were 31 premature infants, 88 infants weighing between 5½ and 9 pounds, and 5 weighing between 9 and 10 pounds. In 1 case the weight was not recorded. Our over-all premature rate is 15 per cent, compared to 25 per cent in the present series. Three of the large babies were brow presentations. Thus the incidence of large babies in face presentations was normal but in brow presentations was high.

There were 4 cases of twin pregnancies. In 3 of the patients the first fetus was a brow or face presentation; in the fourth patient the second fetus was a face presentation.

Four of the face presentations were anencephalic monsters, and 1 had a meningocele and spina bifida. One brow presentation had multiple abnormalities.

In 11 face and 4 brow presentations there was one loop of cord about the neck. There were single cases in which there were two loops of cord about the neck, a knot in the cord, and a knot in the cord with a loop around the neck. Short cords occurred in 1 face and in 1 brow presentation, and there was 1 case of a prolapsed cord. The incidence of these findings were all within normal limits.

There were 3 cases of hydramnios associated with the anomalies mentioned, and 1 case without any anomalies.

Table I lists all factors found in this series which had been previously thought to be responsible for face and brow presentations. Many of these occurred in combinations in the same patients. Contracted pelvis, prematurity, anencephaly, and multiple gestations were the only factors sufficiently increased to be considered of significance as causes of these presentations.

CLINICAL COURSE

In 22 of these cases the membranes ruptured before labor, in 68 during the first

From the Obstetrics Service of the Harlem Hospital, New York.

TABLE I.—FACTORS PREDISPOSING TO FACE AND BROW PRESENTATIONS

Maternal	
Contracted pelvis (of 39 patients who had pelvimetry)	16
Grand multiparity	10
Fibroids	2
Fetal	
Prematurity	31
Umbilical cord pathology	21
Fetal abnormalities	6
Large babies (over 9 lbs.)	5
Hydramnios	4
Multiple gestations	4

stage, in 24 during the second stage, in 3 at cesarean section, and in 8 cases the time of rupture was unknown.

Compared to vertex presentations, the membranes tended to rupture earlier in face and brow presentations, although in most of these cases labor followed within 12 hours.

Prolonged labor occurred in 11 primiparas and 17 multiparas who had face presentations and in 5 primiparas and 6 multiparas who had brow presentations; in other words, in 28 (or 28 per cent) of the face presentations and in 11 (or 50 per cent) of the brow presentations.

We consider a labor prolonged if it lasts more than 18 hours for a primipara or more than 12 hours for a multipara. Prolonged labors, as would be expected, occurred more often in posterior and transverse mentum positions than in anterior face positions.

TIME AND METHOD OF DIAGNOSIS

The early diagnosis of a face or brow presentation is the key to the successful management of these cases. Table II gives the time and method of diagnosis in our cases.

No attempt has been made to separate diagnoses made rectally and those made vaginally. We do not depend on the rectal examination for positive diagnosis. When such an examination indicates an abnormal presentation a sterile vaginal examination is done at once. X-ray studies for pelvimetry as well as for confirmation of the diagnosis are then performed. Face presentations are often thought to be breech presentations on rectal examination. This diagnosis was made at least 3 times in the present series, when vaginal and x-ray examination were not also done. The vaginal examination may be confusing too. Even observation of the presenting part at the vulva can be misleading. A face presentation at the vulva was mistaken for a prolapsed cervix in 1 of our cases. For these reasons, x-ray demonstration of the presentation should be mandatory.

TABLE II.—TIME AND METHOD OF DIAGNOSIS

Time	*No.*	*Method*
Before hospitalization	2	X-ray films taken in prenatal clinic
On admission, but before labor	1	Vaginal examination
On admission, in labor	5	37 by rectal and vaginal examinations
After admission, in 1st stage	36	
After admission, in 2nd stage	10	14 by x-ray alone
At delivery	65	
Not known	6	
Total	**125**	

Tables III and IV give the methods of delivery for the various positions encountered in face and brow presentations.

Twenty-four of 25 premature face presentations were delivered spontaneously or by low forceps. One premature baby in mentum posterior position had to be delivered by cesarean section. Seventy-eight per cent of all full term face presentations were delivered spontaneously or by low forceps. The prognosis for those in anterior face positions was particularly favorable, as the cesarean section rate was only 5 per cent. This figure is lower than the cesarean rate for all deliveries in many hospitals.

The cesarean section rate for the entire series was 12 per cent. The rate of all cases on our service is less than 3 per cent. On the other hand, of 14 full term fetuses in transverse or posterior face positions, 7 were delivered by cesarean section, 5 by Kielland forceps, and 1 by Kielland forceps and Dührssen's incisions. The only fetuses in posterior or transverse positions delivered spontaneously were premature and anencephalic babies, weighing less than 4 pounds 5 ounces, except for 1 in transverse position which was manually rotated.

Seventy-four per cent of the brow presentations were delivered spontaneously or by low forceps, compared to 82 per cent of all face presentations. Twelve (70 per cent) of 17

TABLE III.—METHODS OF DELIVERY IN FACE PRESENTATIONS

Position	*Total*	*Spontaneous*	*Low forceps*	*Manual rotation*	*Kielland forceps*	*Cesarean section*
R.M.A.	57	48	8	0	0	1
L.M.A.	22	18	1	0	0	3
R.M.T.	7	0	0	0	5*	2
L.M.T.	4	1 (anencephalic)	0	1	0	2
R.M.P.	3	1 (anencephalic)	0	0	0	2
L.M.P.	2	1 (premature)	0	0	0	1
M.P.	1	0	0	0	1	0
Unspecified	6	5	0	0	0	1
Total	102	74	9	1	6	12

*Dührssen's incision in 1 case.

full term brow presentations were delivered spontaneously or by low forceps. Three were delivered by cesarean section and 2 by internal podalic version and extraction. The last version for a face or brow presentation was done in 1947. The 3 babies with brow presentations who weighed over 9 pounds were all delivered spontaneously. These figures would indicate that the prognosis for brow presentations is better than it is generally thought to be.

Attempted conversion of a face or brow to an occiput presentation was tried twice but succeeded once in the case of the first of premature twins. Pitocin stimulation was used 8 times; in 1 of these cases delivery was eventually by cesarean section.

MORBIDITY AND MORTALITY

There were 20 stillborns and neonatal deaths in this series. Of these, there were 6 cases of fetal abnormalities incompatible with life, 1 immature fetus, and 6 premature fetuses each weighing less than 3½ pounds.

Of the full term fetuses, 4 of the 7 deaths are considered preventable. The first was delivered in 1942 by extraperitoneal cesarean section after a very prolonged labor. The second was delivered in 1943 by mid-Kielland forceps and Dührssen's incisions. The third was delivered in 1947 by version and extraction after an unsuccessful attempt with Kielland forceps. The fourth case was delivered in 1948 by mid-Kielland forceps after a very prolonged labor. Since 1948, we have not had a preventable fetal death.

No unusual maternal morbidity was noted, nor were there any maternal deaths.

TREATMENT

When the diagnosis has been made early, every patient is allowed a trial of labor unless there is a complicating factor such as a markedly contracted pelvis, elderly primiparity, or severe pre-eclampsia. The labor is allowed to continue as long as the patient progresses and the fetal heart remains good. We expect prolonged labors in these cases and supportive therapy is given. If the labor is desultory, there is no objection to judicious stimulation with a dilute solution of pitocin intravenously.

We continue to follow the maxim, "If the face is making progress, leave it alone." If descent of the presenting part is not progressive, however, cesarean section is considered. The major pitfall, in judging the progress of a face or brow, lies in overesti-

TABLE IV.—METHODS OF DELIVERY IN BROW PRESENTATIONS

Position	*Total*	*Spontaneous*	*Low forceps*	*Version and extraction*	*Midforceps*	*Cesarean section*
R.F.A.	9	5	0	1	1*	2
L.F.A.	3	2	1	0	0	0
R.F.T.	1	0	0	0	0	1†
L.F.T.	1	0	0	1‡	0	0
F.A.	3	2	1	0	0	0
Unspecified	6	6	0	0	0	0
Total	23	15	2	2	1	3

*Preceded by manual flexion and rotation.
†No labor, severe pre-eclampsia.
‡After a failed Kielland forceps.

mating the degree of engagement. When the presenting part is felt at the ischial spines the trachelobregmatic diameter, which is the widest of the two engaging diameters, is still well above the inlet. The chin may be visible at the vulva between pains, and yet the head may still be unengaged. We therefore teach that in face and brow presentations "It's higher than you think." We judge the degree of engagement by two methods: first, by vaginal or rectal examination to determine if the hollow of the sacrum is filled, and secondly, by suprapubic palpation of the fetal head, preferably under general anesthesia. If the hollow of the sacrum is not filled by the head, and if a substantial portion of the head can be felt suprapubically, engagement has not occurred. In such a case, despite the station of the presenting part, delivery from below should not be attempted.

If engagement has taken place and spontaneous rotation of a transverse or posterior chin does not occur, Kielland forceps are applied for rotation and extraction. The mentum is used as the point of direction. A fetus in persistent transverse brow position should be delivered by cesarean section. The only place for a version and extraction is in the delivery of the second of twins, or possibly in the case of a malformed or dead fetus. In the case of a dead fetus, craniotomy and delivery by an axis-traction forceps, such as the Dewees forceps, may be done.

COMPARISON WITH PREVIOUS REPORTS

A comparison of this series with the previous series from the Harlem Hospital reveals marked decreases in fetal and maternal mortality rates which dropped from 20 to 6.3 per cent and from 3 to 0 per cent respectively. Much of the improvement must be attributed to the substitution of cesarean section for version and extraction. Twenty-six versions were done in the first series and only 2 since.

As for the etiologic factors, multiparity was not significant in the present series, although considered an important factor before. The incidence of premature face and brow deliveries has doubled. The rate for spontaneous and low forceps deliveries rose from 60 to 81 per cent.

We have also reviewed other recent papers in an attempt to determine the current concepts on etiology and treatment, and to compare results (1-11).

There is widespread, if not unanimous, agreement on the following points: (1) the incidence of face presentations is regularly about 1 in 550; (2) fetal abnormalities are common, but loops of cord about the neck, neck tumors, hydramnios, dolichocephaly, pelvic tumors, and placenta previa are not considered of etiologic significance; (3) the membranes tend to rupture early; but (4) the diagnosis of face or brow presentation is not made in half of the cases until late in labor.

Most authors, including ourselves, agreed that labor was prolonged and that the incidence of contracted pelvis was high, although a few did not find this so. The majority did not consider prematurity in the etiology of face and brow presentations, but a minority of us did. Ours was the only series which had a high incidence of twins. Opinion was equally divided as to the significance of multiparity and large babies as etiologic factors. There was little agreement on the incidence of brow presentations, the figures ranging from 1 in 667 to 1 in 3,543.

The methods of delivery varied a great deal. Spontaneous and low forceps delivery rates ran from 22 to 81 per cent, cesarean section from 0 to 30 per cent, and version and extraction from 2 to 46 per cent. The series with the lowest rates of spontaneous deliveries had high rates of version and extraction. Maneuvers to convert face and brow presentations into occiput presentations were not employed very often, and were successful half the time or less.

Fetal mortality varied from 6.3 to 20 per cent. In all but 1 of the various series, fetal salvage was least after version and extraction. Maternal mortality was low in all series, most deaths having occurred in preantibiotic days. Maternal morbidity was noticeably

higher in those series in which the most versions had been done.

COMMENTS

As a result of this study, several facts have become apparent. The only factors which consistently predispose to face and brow presentations are contracted pelves, prematurity, and fetal abnormalities (usually anencephaly). The fetal head is thus either too large or too small for the pelvic inlet. The role of multiparity and a lax abdominal wall with a faulty uterine axis is debatable. On the other hand, pathologic cord and loops of cord about the neck, dolichocephaly, neck tumors, and pelvic tumors are no longer considered basic causes of hyperextension by any modern investigators. The senior author has seen 4 and 5 loops of cord about the necks of fetuses without hyperextension and has never seen congenital neck tumor which produced a face or brow presentation.

Our second observation is that a diagnosis is rarely made by abdominal palpation alone. Even in the most experienced hands, it may be most difficult to judge on which side the cephalic prominence lies. For didactic purposes, abdominal palpation should be routinely employed. In actual practice, however, x-ray examination has relegated abdominal palpation to the background.

Another point noted is that the time honored external and internal maneuvers designed to convert an extended into a flexed head are no longer used much. We are aware that some skilled obstetricians state that they can convert most face and brow into occiput presentations, but we have had little success with these maneuvers.

Probably many of the successful conversions are done before or very early in labor. On the other hand, we have all seen many conversions take place spontaneously. Weighed against the occasional success of a manual conversion are the complications which may arise in the attempt, the occurrence of spontaneous conversion, and the high incidence of spontaneous deliveries of face and brow presentations.

The fact that any type of conversion may take place spontaneously indicates that the position and presentation must be checked frequently throughout the course of labor. Additional roentgenograms should be taken without hesitation when there is any doubt of the finding. In the present series, the spontaneous conversions which occurred and were demonstrated roentgenographically were as follows: occiput to face in 12 cases, brow to face in 12, occiput to brow in 3, breach to face in 2, transverse lie to face in 1, and transverse lie to brow presentation in 1 case.

Some authors question the existence of a "primary" face presentation. They believe that face presentations are secondary to occiput or brow presentations once labor gets under way. However, in this series, we have roentgenograms of 2 face presentations well before the onset of labor.

In a detailed study and discussion of the etiology of face and brow presentations, White takes an opposite position. He believes these presentations are always primary, the cause being increased tone of the extensor muscles of the back and neck of the fetus. However, as indicated before, we have seen many cases of occiput presentations prior to labor become converted into face and brow presentations once labor ensued. Therefore, we do not believe this factor is the underlying cause of deflection attitudes.

SUMMARY

1. One hundred and two face and 23 brow presentations occurred in 50,345 deliveries at Harlem Hospital from July 1, 1942 to June 30, 1956. The incidence of face presentations was 1 in 494. The incidence of brow presentations was 1 in 2,189.

2. Of all the presumed etiologic factors, contracted pelvis, prematurity, and fetal abnormalities were the only ones considered significant as causes for face or brow presentations.

3. Multiparity, hydramnios, loops of cord about the neck, and pelvic tumors occurred in a normal incidence.

4. Early rupture of the membranes and prolonged labor were frequently encountered.

5. Half the cases were not diagnosed until the time of delivery. Abdominal palpation was of little diagnostic value.

6. The diagnoses was made by roentgenography alone in 16 (30 per cent) of those cases diagnosed before delivery. Roentgenography was used routinely to confirm a diagnosis made by vaginal examination, and pelvimetry was usually done at the same time.

7. In 82 per cent of face presentations delivery was spontaneous or by low forceps, in 12 per cent by cesarean section, and in 6 per cent by Kielland forceps. Cesarean section was used in only 5 per cent of mentum anterior presentations.

8. Seventy-four per cent of the fetuses in brow presentation were delivered spontaneously or by low forceps. Three were delivered by cesarean section and 2 by version and extraction.

9. The corrected fetal mortality was 6.3 per cent.

10. Maternal morbidity was normal and there were no maternal deaths.

11. The management of face and brow presentations at Harlem Hospital has been given.

12. The results of other writers have been compared.

CONCLUSIONS

1. Contracted pelvis, prematurity, and fetal abnormalities (usually anencephaly) predispose to face and to brow presentations.

2. In half of the cases of face and brow presentations labor will be uneventful and the diagnosis not made until delivery. The other half will present the problems.

3. Roentgenography for diagnosis and for pelvimetry is a most essential factor in the management of these cases.

4. In all instances of face and brow presentations a generous trial of labor should be allowed, unless there are complicating factors. The high incidence of spontaneous deliveries in brow as well as face presentations justifies this policy.

5. The prognosis for spontaneous delivery of the fetuses in anterior positions is excellent. Persistent transverse and posterior positions constitute the main challenge to the obstetrician.

6. Version and extraction and manual conversion to an occiput presentation should no longer be used in the management of face and brow presentations.

7. Under the method of treatment presented, maternal and fetal mortality in face and brow presentations should not be greater than normal.

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A CLINICAL STUDY OF 1,060 PATIENTS WITH ACUTE CHOLECYSTITIS

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OUR PURPOSE in the present report is to evaluate the results of the treatment of acute cholecystitis at the Charity Hospital in New Orleans over a period of 18 years (1938 to 1955, inclusive). In recent years, most articles pertaining to this disease have been concerned only with operative cases. This fact, of course, reflects the current general tendency toward early operation in the acute attack. Perhaps inclusion of the conservatively treated cases in such reports would afford a more accurate picture of the problem of acute cholecystitis.

MATERIAL

The present series consists of 1,060 cases, including all cases in which the diagnosis of acute cholecystitis was made on all services of the Charity Hospital in New Orleans from 1938 to 1955. Only the cases of those patients are included who were proved by laparotomy or autopsy to have acute cholecystitis, or, if laparotomy or autopsy was not performed, who presented a clinical picture upon which a positive diagnosis could be established beyond reasonable doubt.

The age distribution by decades is presented in Figure 1. The youngest patient was 6 years old, the oldest 92 years. Patients over 60 years of age comprised 28.1 per cent of the material and 72.1 per cent of the deaths.

Eighty per cent of the patients were females, and 20 per cent were males (Table I). Whites were afflicted much more often than negroes, the ratio being almost 2 to 1, while the ratio of whites to negroes in the Charity Hospital population during the period under study was approximately 2 to 3. The case incidence by race and sex was for white females, 500; negro females, 355; white males, 162; and negro males, 43.

Six hundred (56.6 per cent) of the patients had had symptoms of acute cholecystitis for 48 hours or less before their admission to the hospital, whereas the remainder (43.4 per cent) were later cases (Table I). It is of interest that in 25 per cent of the cases there was no past history suggesting biliary tract disease.

Cholelithiasis was present in 88.1 per cent of the operative cases, and choledocholithiasis in 8.6 per cent.

Of the 679 patients submitted to laparotomy, 65 (9.3 per cent) had a perforation of the gallbladder. This figure is a conservative one because it includes only those cases in which the operative note specifically described the presence of a gross defect in the gallbladder wall. Generalized bile peritonitis resulting from perforation into the free peritoneal cavity was encountered in 21 (3 per cent) of the surgical cases. In 30 (4.4 per cent), the perforation was localized to the pericholecystic area. There were 14 instances (2.1 per cent) in which there was perforation into an adjacent viscus, such as the liver or duodenum. In addition to these 65 cases of gross perforation of the gallbladder encountered at operation there were 7 others proved at autopsy among the conservatively treated cases. Six of these 7 patients died of generalized bile peritonitis.

TREATMENT AND RESULTS

In the entire series of 1,060 cases there were 68 deaths, a mortality of 6.4 per cent. When the 6 patients who were moribund on

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TABLE I.—ACUTE CHOLECYSTITIS: MATERIAL AND RESULTS

	No. of cases	*Per cent of cases*	*No. of deaths*	*Mortality per cent*
Total cases	1060	100	68	6.4
Sex				
Male	205	19.3	22	10.7
Female	855	80.7	46	5.4
Race				
White	662	62.5	50	7.5
Negro	398	37.5	18	4.5
Sex and race				
White male	162	15.3	18	11.1
White female	500	47.2	32	6.4
Negro male	43	4.0	4	9.3
Negro female	355	33.5	14	3.9
Duration of acute symptoms				
Less than 48 hours	600	56.6	19	3.2
49 to 72 hours	148	13.9	10	6.7
3 to 7 days	189	17.8	21	11.1
More than 7 days	102	9.6	16	15.7
Treatment				
No operation	381	35.9	21	5.5
Operation	679	64.1	47	6.6
Cholecystostomy	96	9.1	15	15.6
Cholecystectomy	435	41.0	17	3.9
Cholecystectomy and choledochostomy	140	13.2	11	7.9
Miscellaneous	8	.8	4	50.0

admission and the 6 others whose acute cholecystitis with perforation and generalized bile peritonitis was recognized only at autopsy are excluded from the totals, there were 1,048 patients with 56 deaths, a mortality of 5.3 per cent.

The over-all mortality of 6.4 per cent is excessive, but an encouraging degree of improvement occurred during the 18 year period under study. A comparison of the two 9 year periods indicated a decline in mortality from 9.8 per cent to 4.9 per cent (Fig. 2). The extent of the decline in the mortality rates in the conservatively treated group and in the operative group was about the same. The major factors influencing prognosis were the age and sex of the patient, the duration and severity of the attack, and the method of treatment (Table I).

Patients over 60 years of age comprised 28.1 per cent of the material and 72.1 per cent of the deaths. The death rate in patients up to and including 60 years of age was 2 per cent; in those above 60 years old it was 16 per cent (Fig. I). The progressive increase in mortality rate in the sixth, seventh, and eighth decades is predictable. It is noteworthy that only 1 death occurred among the 322 patients 40 years of age or under. This 1 fatal case was that of a 35 year old negro female who entered the hospital 4 days after the onset of acute cholecystitis. There were associated obesity, hypertensive cardiovascular disease, and severe chronic pyelonephritis. Three days following cholecystectomy she developed cardiac and renal failure and eventually died of uremia.

The case fatality rates in males and females were 10.7 per cent and 5.4 per cent respectively (Table I). While there was a much higher proportion of older males this factor did not seem to explain this difference fully. The difference in the mortality rates in the two races would at first glance appear striking. However, the difference in the age distribution of the two groups seems responsible for it.

Of the patients seen within the first 48 hours of their illness only 3.2 per cent died; the mortality was more than 3 times as high (10.7 per cent) in those who had been ill more than 48 hours.

In Table II are summarized more detailed data concerning the relationship of method of treatment and mortality. Of the 1,060 patients comprising this series 381 (35.9 per cent) were treated without operation, 96 (9.1 per cent) with a cholecystostomy, 435

(41 per cent) with a cholecystectomy, 140 (13.2 per cent) with cholecystectomy and choledochostomy, and 8 (0.8 per cent) with miscellaneous operations.

The mortality rate was 5.5 per cent in the 381 patients with acute cholecystitis who were not operated upon. As mentioned previously, 12 of the 21 deaths in this group occurred in patients who were either moribund on admission or whose cholecystitis and generalized bile peritonitis were recognized only at autopsy. If these 12 patients are excluded from the totals (they received no treatment for acute cholecystitis), there were 369 patients in the nonoperative group with 9 deaths, a mortality of 2.4 per cent.

During the 18 year period under scrutiny 35.9 per cent of the patients were treated without operation; and it is of interest that this figure remains unchanged in the two 9 year periods involved. A comparison of the mortality rates for the two periods indicates a decline from 9.2 per cent (1938 to 1946) to 3.8 per cent (1947 to 1955).

In addition to the 381 patients who had no operation there were 114 others for whom nonoperative treatment was planned and embarked upon but abandoned because of progression of signs and symptoms. Of these 114 patients whose conservative treatment was unsuccessful and who had "delayed forced" operations 16 died, a mortality of 14 per cent. The mortality rate was much lower (4.9 per cent) in 141 cases of "delayed elective" operations. In this category were those patients whose initial conservative treatment was successful and for whom elective operation was later performed during the same hospital admission.

Of 679 patients with acute cholecystitis who were operated upon 47 died, giving a mortality rate of 6.6 per cent. Cholecystostomy was performed in 96 (9.1 per cent of the entire series and 14.1 per cent of the operative cases) with a mortality of 15.6 per cent. A comparison of the two 9 year periods of this study indicates no significant difference with respect to the relative frequency of or mortality rate from cholecystostomy.

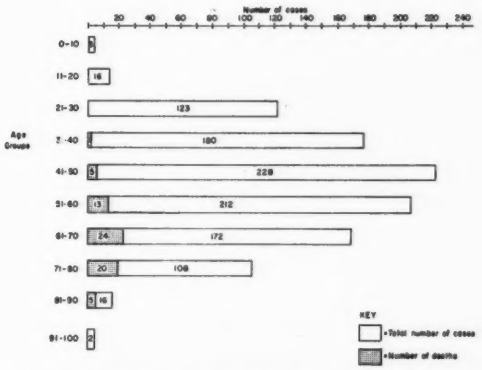

FIG. 1. Distribution and mortality by age in 1,060 cases of acute cholecystitis. Patients over 60 years of age comprise 28.1 per cent of the material and 72.1 per cent of the deaths. The death rate of patients 60 years of age and younger is 2 per cent; above 60 years it is 16 per cent.

Cholecystectomy was the operation performed in 435 patients (41 per cent of the entire series and 64 per cent of the operative cases) with 17 deaths, a mortality rate of 3.9 per cent. During the second half of the period under study 308 patients with acute cholecystitis were treated by cholecystectomy with a mortality rate of 1.9 per cent.

Cholecystectomy and choledochostomy were carried out in 140 patients, or 20.1 per cent of all patients operated upon. Eleven of the 140 patients died, a mortality rate of 7.9 per cent, which is twice that for cholecystectomy alone. Stones were recovered from 31.6 per cent of the ducts explored. Among the patients submitted to choledochostomy the operative mortality rate seemed to be twice as high in the group with choledocholithiasis as it was in the group in which no common duct stone was encountered.

There were 4 deaths among the 8 patients having miscellaneous operations such as enterolithotomy, choledochostomy alone, and laparotomy alone.

In Table III are listed the major postoperative complications occurring in the 679 operative cases.

DISCUSSION

For a detailed discussion of the clinical and pathologic features of acute cholecystitis,

TABLE II.—MORTALITY ACCORDING TO METHOD OF TREATMENT OF ACUTE CHOLECYSTITIS

Form of treatment	*No. of cases*	*Per cent of total cases*	*Per cent of operative cases*	*No. of deaths*	*Mortality, per cent*
No operation	381	35.9		21	5.5
Operation	679	64.1		47	6.6
Cholecystostomy	96	9.1	14.1	15	15.6
Cholecystectomy	435	41.0	64.0	17	3.9
Cholecystectomy and choledochostomy	140	13.2	20.1	11	7.9
Miscellaneous operations	8	.8	1.8	4	50.0
Totals	1060			68	6.4

TABLE III.—COMPLICATIONS OF OPERATION IN ACUTE CHOLECYSTITIS

Complication	*Cholecystostomy*	*Cholecystectomy*	*Cholecystectomy and choledochostomy*	*Total*
Wound infection	11	26	12	49
Wound dehiscence	2	15	6	23
Wound hematoma	1	10	1	12
Atelectasis	9	21	7	37
Bronchopneumonia	8	14	7	29
Cardiac decompensation	9	6	6	21
Thrombophlebitis	2	6	4	12
Thromboembolism	1	2	1	4
Uremia	1	5	1	7
Myocardial infarction	1	1	1	3
Subphrenic abscess	2	4	2	8
Subhepatic abscess	3	2	1	6
External biliary fistula	7	2	1	10
Bile duct injury	0	5	2	7

the matter of timing in the surgical treatment of the disease and the multiple factors influencing the prognosis in a series of 462 consecutive operative cases at Charity Hospital the reader is referred to the 1952 report of DeCamp and associates. With their expressed conclusions we are in general accord.

The controversial issue of early versus delayed operation for acute cholecystitis will not be debated here. It is a question which must be decided on the basis of mortality and morbidity, and our analysis of these 1,060 cases fails to provide an unequivocal answer. It is our impression that most patients with acute cholecystitis should be operated upon after a few hours of careful study and adequate preparation.

Although the mortality rate declined from 9.8 per cent for the period 1938 to 1946 to 4.9 per cent for the period of 1947 to 1955, and during the latter era 308 patients were treated by cholecystectomy with a mortality rate of only 1.9 per cent, these rates remain too high. To DeCamp and associates' list of major factors responsible for this excessive mortality in acute cholecystitis in Charity Hospital we would add at least three others: diagnostic errors, failure to apply vigorously the well recognized principles of conservative therapy in those cases selected for nonoperative treatment, and frequent failure to choose the proper operation in the surgically treated cases.

Three patients died on the medical service of unsuspected acute cholecystitis with perforation and generalized bile peritonitis proved at autopsy. A similar situation obtained in 3 others whose acute cholecystitis developed while they were convalescing from unrelated operations. In one-third of the conservatively treated patients who died the correct diagnosis was not made prior to autopsy. The preoperative diagnosis was incorrect in one-third of the patients who died following operation. Delayed diagnosis resulting in delayed treatment was largely responsible for the death of several patients. The extent to which errors in diagnosis contribute to the mortality in acute cholecystitis has been emphasized in the literature.

The simple scout film of the abdomen strongly suggested the correct diagnosis in

many cases. Radiopaque calculi were demonstrated in 39.6 per cent of the patients who had such an examination and in whom stones were later found at operation.

The principles of nonoperative treatment of acute cholecystitis are well recognized. They include the correction of fluid, electrolyte, and blood volume deficits by appropriate parenteral therapy; rest of the intestinal tract by avoidance of oral intake of fluid or food and the use of continuous nasogastric suction; the relaxation of the spastic sphincter of Oddi by the administration of anticholinergic drugs; alleviation of pain and apprehension by sedatives; the prevention and treatment of infection by antibiotics; and careful and frequent re-evaluation of the patient's condition; and abandonment of conservative treatment should it be warranted by failure to improve or the progression of signs and symptoms.

Many of the 381 patients in this series who were treated without operation and a number of the 114 patients who had "forced delayed" operations were not managed by the aggressive application of the therapeutic principles listed. More than one-half of the conservatively treated patients who died actually had no treatment directed at the underlying disease process.

The ideal operation for the patient with acute cholecystitis is cholecystectomy and, when indicated, choledochostomy. Simple cholecystostomy is the operation of choice when the patient's general condition or local anatomic and pathologic findings are such as to render too hazardous the performance of a more definitive procedure.

Ross and Dunphy (4) have emphasized the value of cholecystostomy as a life-saving procedure and have urged that it be carried out as a planned operation under local anesthesia and that it not be reserved merely as a means of escape from a technically difficult situation. These authors reported a series of 134 operative cases of acute cholecystitis, and their remarkably low mortality of 1.5 per cent was attributed in considerable degree to the judicious employment of cholecystostomy

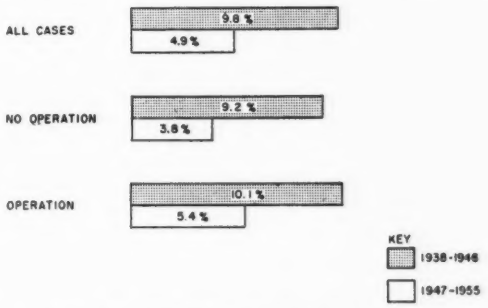

FIG. 2. Mortality in acute cholecystitis during the period from 1938 to 1946 as compared with the years 1947 to 1955.

in the desperately ill patient. Three-fourths of their cholecystostomies were carried out as planned procedures under local anesthesia. At the Charity Hospital three-fourths of the cholecystostomies were "forced" operations performed under general or spinal anesthesia and resorted to because of local anatomic hazards or the poor general condition of the patient.

How many of the Charity Hospital patients who died without operation or who failed to survive cholecystectomy or "forced" cholecystostomy could have been saved by planned cholecystostomy under local anesthesia? A careful review of the hospital records of the 68 patients who died leads us to believe that perhaps one-third of them would have survived simple drainage of the gallbladder under local anesthesia.

Common duct exploration was carried out in 20 per cent of the operative cases in this series. This figure is higher than the 8.7 per cent reported by Glenn but much lower than the 42 per cent recorded by Dunphy and Ross (2). Since the addition of choledochostomy to cholecystectomy increased the operative risk two-fold and since more than two-thirds of the ducts explored did not contain stones, we are in accord with those who suggest that perhaps the less urgent indications for choledochostomy should be ignored in the poor risk patient and in the presence of major anatomic hazards due to the acute inflammatory process.

SUMMARY

An analysis of 1,060 cases of acute cholecystitis occurring at the Charity Hospital in New Orleans during the 18 year period from 1938 to 1955 has been presented. The mortality rate was 6.4 per cent.

The major factors responsible for this excessive mortality have been discussed.

Thirty-six per cent of the patients were treated without operation, 8.1 per cent by cholecystostomy, 41 per cent by cholecystectomy, 13.2 per cent by cholecystectomy and choledochostomy, and 0.8 per cent by miscellaneous operations.

Nonoperative treatment was attended by a mortality of 5.5 per cent. Errors in diagnosis contributed to more than one-half of these deaths.

The mortality for cholecystectomy was 3.9 per cent. During the second half of the period under study 308 patients had this operation with a mortality of 1.9 per cent.

The high mortality rate of 15.6 per cent associated with cholecystostomy was not unexpected in view of the type of patient for whom the operation was selected.

In 140 patients treated by cholecystectomy and choledochostomy the mortality was 7.9 per cent.

Since 20 per cent of the operations included choledochostomy and stones were found in only 31.6 per cent of the ducts explored, and since the addition of common duct exploration doubled the risk of operation, it has been suggested that in certain patients with acute cholecystitis the less urgent indications for performing choledochostomy should be disregarded.

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EDITORIALS

TOTAL VERSUS RADICAL PARTIAL RESECTION FOR CANCER OF THE STOMACH

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AT THE PRESENT TIME, the only available method for treatment of gastric cancer is surgical resection, and during the past few years the trend has been toward a more radical type of surgical extirpation, such as total gastrectomy, with the hope of improving the results of treatment of gastric carcinoma. The operative mortality of total gastrectomy has very nearly approached the operative risk of partial gastrectomy. With improvements in modern surgery and better understanding of postoperative physiology and postoperative care, we can confidently expect this operative mortality to decrease even further as more experience is gained by the surgeon in this field of radical surgery.

A larger number of total resections have been done up to the present time, and it is reasonable to attempt to assess the results of such radical surgery in terms of improvements in these results. Can the results of treatment of cancer of the stomach be improved by removal of the stomach, or are there other factors of far greater importance to be considered than the more radical removal of all of the gastric wall? The surgeon not only must consider the possibility of higher cure rate, but also must weigh the limitations of such extensive resection of the stomach before any true evaluation of the results of such radical treatment can be made. The mere fact that the operative mortality of total removal of the stomach has steadily decreased does not justify the routine use of such extensive surgery unless a higher rate of curability or an improvement of life expectancy after surgical resection can be confidently expected in an increasing number of patients subjected to this more radical procedure.

Furthermore, the complexity of problems arising in the patient after total removal of the stomach must not be overlooked. These after-effects are disturbing both to the surgeon and to the patient. They often result in considerable disability to the patient and, too frequently, fail to respond to any type of therapy. Nutritional problems, weight loss, postprandial discomfort, dumping syndrome, and anemia are just a few of the difficulties encountered after total gastrectomy.

At the clinic we have employed total resection of the stomach in 246 patients with an operative mortality of 8.2 per cent (over a 10 year period) as opposed to an operative mortality of 5.7 per cent after partial gastrectomy. During the same period of time 20 to 30 per cent of all patients who had resections for gastric carcinoma had total removal of the stomach. I agree with Allen[1] that total gastrectomy should be utilized only in those patients whose obvious disease process could not be removed completely otherwise. Furthermore, total gastrectomy should be employed only in those patients whose disease

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[1]ALLEN A. W. Cancer of the stomach. Surg. Gyn. Obst. 1951, 92: 757-759.

may be curable by surgical extirpation, and only when all gross manifestations of the cancer can be removed by surgery of such magnitude. Total gastrectomy should never be done as a palliative procedure and its use for such a purpose cannot be condemned too vigorously.

There is a paucity of case reports in the literature of patients surviving for 5 years after total gastrectomy, so that a basis for comparing results of reported series does not exist. Similarly, any attempt to compare curability of total gastrectomy with that of partial gastrectomy is of little value because most of the reported results are based upon total gastrectomy in cases of extensive gastric cancer. In our own group of cases, only 14.1 per cent of patients who had total gastrectomy lived 5 years or longer after operation.

In the treatment of gastric carcinoma total removal of the stomach undoubtedly has a definite place, but great care and discrimination should be used by the surgeon in selecting patients upon whom such an extensive operation should be done. Total gastrectomy, however, can be a most valuable procedure when properly applied; we would urge its use in carefully selected cases.

One cannot assume that carcinoma recurring in the nonresected portion of the stomach is prima facie evidence that total gastrectomy might possibly have cured the patient, since the initial resection may not have been carried far enough beyond the tumor at the time of the partial resection to make it a curative resection. Complete excision of all lymphatic drainage areas of the stomach is an absolute necessity, and this procedure requires very careful dissection of all groups of gastric lymph nodes. Tumor cell drainage into the peripancreatic lymphatics can be eliminated only by total pancreatectomy, which would increase the operative risk tremendously, with very questionable improvement in the curability rate. Partial resection of the pancreas in addition to a total gastrectomy, as advocated by some surgeons, has only served to increase the operative mortality rate, except in instances of direct invasion by extension. This fact has been noted in several reports in the literature and has not resulted in increased curability of gastric carcinoma.

There is no convincing evidence as yet that total gastrectomy should be employed as a routine procedure in the surgical treatment of gastric cancer. In my opinion, however, radical partial resection of the stomach, with resection of the omentum and lymph nodes, plus excision of the spleen is still the most satisfactory method in the majority of cases of gastric cancer. Furthermore, total gastrectomy must be employed in about one-third of all cases of gastric cancer.

Progress in the treatment of this disease is still to a very great measure related to earlier recognition of the disease, brought about by constant dissemination of knowledge of the frequency of gastric cancer, an awareness of the probable precursors of gastric carcinoma, and suspicion on the part of the physician of carcinoma in any individual who has persistent gastric distress.

INDUCED HYPOTHERMIA DURING SURGERY

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EXPERIENCE WITH HYPOTHERMIA as an adjunct to general anesthesia for surgery has now accumulated for nearly 7 years. At the time of the present writing (1956) the question might be asked, has hypothermia come of age? The answer must be equivocal. It has become of age in a fashion similar to a senior medical student's coming of age in the field of medicine. It has certainly not progressed to the equivalent of what one might expect from an established practitioner because too little is known concerning altered physiology during hypothermia to assign to this technique a mature status.

For many years, money has been expended on air-conditioning so that surgeons and other operating room personnel might enjoy a climate which would let their physiologic processes function more efficiently. No such benefit was afforded the patient, however, until recently. The patient was covered with drapes until water could not evaporate from the surface of his skin and surface heat transfer was almost impossible. Warm operating room lights shone on him and fluids were not always given to him. Approximately 7 years ago McQuiston described the beneficial value of cooling pediatric patients during cardiac surgery. His concept was not particularly that of using hypothermia for he desired chiefly to prevent hyperthermia. However, he recognized that bodily metabolism is diminished as temperature is lowered within certain unknown limits.

Shortly thereafter, Bigelow and Boerema independently reported the results of their experiments with dogs taking advantage of lowered metabolism subsequent to lowered temperature for complete occlusion of circulation so that they could examine the interior of the heart. The protective value to the brain of hypothermia during complete circulatory occlusion for cardiac surgery is obvious. This procedure is today indicated for several operations when supraventricular incisions are to be made by the surgeon, for it has proved to be quite satisfactory in this respect. Our last 26 consecutive open-heart procedures have been carried out without a fatality. Measures to which gratifying results may be largely attributed are: (1) complete relaxation of the anesthetized patient before commencing rapid cooling; (2) maintenance of the temperature of the patients above 29 degrees C., which has tended to avoid hemorrhagic diatheses and cardiac arrhythmias; (3) use of diathermy for control of declining temperatures as well as for rewarming the patient; and (4) intermittent occlusion and reinstitution of blood flow when definitive surgery requires more than 6 minutes.

Hypothermia with circulatory occlusion and perfusion of the coronary arteries by using oxygenated blood has been of value when ventricular incisions were made. This approach affords the surgeon direct vision but leaves the problem of ventricular fibrillation during manipulations of the cold ventricle unsolved. Extracorporeal normothermic circulation circumvents this fibrillatory tendency but unfortunately it has been too frequently associated either with hemorrhagic diathesis at the time of surgery or with unexplained arrhythmias following surgery. Herein lies a field that demands further investigation. One cannot but wonder whether it is better to seek conditions under which fibrillation is likely to be avoided during hypothermia, or whether it would be more fruitful to try to offset difficulties which follow the use of artificial circulation. It is to be hoped that both lines of

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endeavor will be vigorously pursued. While both techniques may ultimately be of value, mortality rates reported to date can give physicians no basis for being satisfied with the present status of either method.

The use of hypothermia for regional occlusion of circulation has been beneficial in many respects. The brain, liver, kidneys, and legs have all been given hypothermic protection during surgical procedures. It is obvious that heart-lung by-pass can be of no help in this type of work. Hypothermia therefore has become an established adjunct to anesthesia but complications have been numerous and optimum conditions for its use remain to be elucidated.

Utilization of hypothermia for patients in shock might be of considerable value, but on a medicolegal basis, who wants to use it first? Reports have already appeared, though, concerning the beneficial value of chlorpromazine with very mild hypothermia for such patients. One never has a control on the same patient, so exact evaluation has been difficult. Although logic indicates that hypothermia be used in shock, proper methods for its application have not been elaborated.

When hypothermia is used during surgery, less anesthetic agent need be used. In many cases done in the general surgical field such a measure can be beneficial, but the safe temperature level is indefinite. It should be realized that hypothermia carried to extreme levels will result in death. One therefore cannot say that if a little hypothermia is a good thing, more will be better. We must eventually determine the proper limits and conditions for this technique. Such determination will require solution of the following problems among others:

1. The hemorrhagic tendency noted in many of these cases may be a function of temperature or perhaps of other factors. If it is a matter of temperature, wherein does safety lie? Perhaps 30 degrees C. should be a minimum temperature so that bleeding diathesis may be avoided. Reports have appeared of excessive bleeding at normal temperatures when multiple transfusions have been given, so that one cannot blame all the tendency toward bleeding specifically on hypothermia. Platelet count is reportedly lower during hypothermia in dogs. Much more information is needed in this area. If factors other than temperature are involved, what can be done about them? Can transfusion of platelets be accomplished?

2. How rapidly should patients be cooled? No objective comparisons have been published.

3. Is direct or surface cooling less traumatic for the patient? Each of several investigators has claimed that one or the other method is preferable but the two procedures have not generally been compared by the same personnel. The direct cooling of blood may have advantages when the diagnosis is not certain before cardiac surgery. Here the choice of cooling or not cooling may be made after entering the chest. If the surgical procedure is to be done with only regional occlusion of circulation, the direct cooling of blood would not produce this advantage. Serious complications have followed the use of both methods. Information is available indicating that the human adrenocortical response to surface cooling is significant. After such response has occurred the individual may be protected against further adrenal response to surgical stress. No data are available concerning the adrenocortical response to the direct cooling of blood.

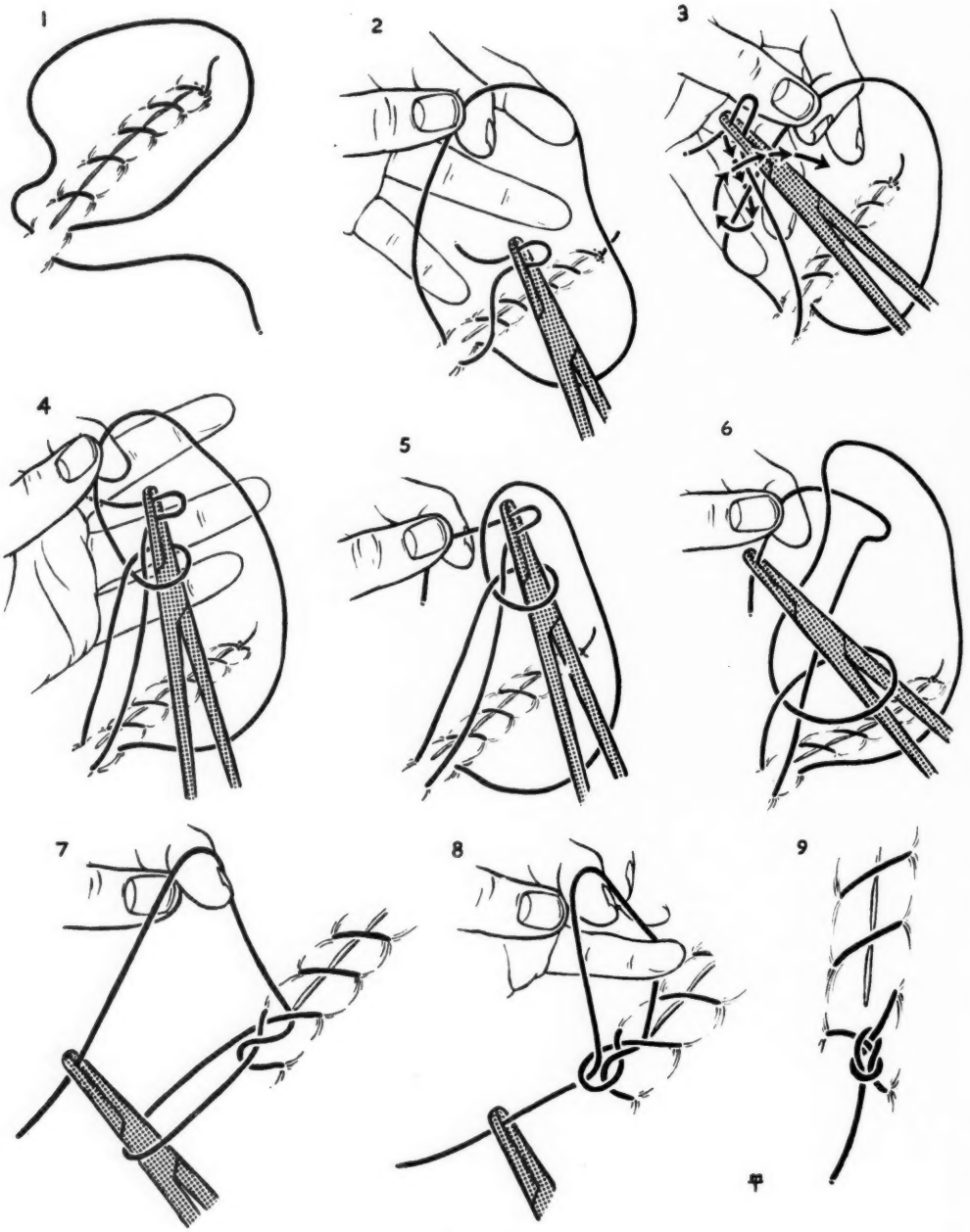
4. Measurement of blood volume still poses a problem which seems to be more acute during hypothermia than at normal temperatures. Equilibration time of substances added to blood for measurement is prolonged to an unknown degree during hypothermia. Measurement of blood volume by the radioactive iodinated albumin method has been of great value during hypothermia, but this method requires considerable time and equipment as well as a technician trained in its use. A rapid method for determination of blood volume would be very valuable in many phases of surgery and, particularly, for cooled patients.

5. The effect of hydrogen ion concentration or of carbon dioxide on physiologic activity during hypothermia needs better definition. Reports have stated that either an excess of carbon dioxide or diminution of carbon dioxide is valuable for the avoidance of ventricular fibrillation in the cold heart. Obviously, both cannot be entirely correct. The optimum hydrogen ion concentration value may be only a facet of a more comprehensive problem. Although most surgeons operate while the heart is beating slowly, survival from intracardiac procedures has recently been declared better when the heart has been stopped. Perhaps this occurs because metabolism is lower. Data are not adequate to decide whether cardiac manipulation may be performed in a safer manner with or without a continuous heart beat. It has also been stated recently that cooled hearts may be stopped more easily with a high concentration of carbon dioxide than with a low concentration. On the basis of the present literature, an unbiased observer would conclude that the proper hydrogen ion concentration or rate of heart beat best for the patient is an unsolved enigma.

6. Reported pathologic changes which may occur in organs of individuals that have been cooled are not consistent from observer to observer. One laboratory finds necrotic or scarified areas in the heart of almost every individual cooled whereas others find no changes whatsoever. There is an accumulation of evidence that a liver may be damaged if hypothermia is prolonged, say beyond 12 hours. There is much speculation that a liver having poor function preoperatively may predispose the patient to hemorrhagic diathesis. All these factors need intensive accurate investigation.

With transportation as rapid and as easy as it is today, it seems incomprehensible that surgeons would use hypothermia without having seen the technique used. Reports by word of mouth, however, indicate that this situation has occurred and that the results have not been desirable in many cases. A recent editorial in SURGERY, GYNECOLOGY AND OBSTETRICS emphasizes the value of skill in surgery. If skill is so essential in general surgery where procedures are more or less standardized, it would seem to be all the more necessary when new techniques are being developed. Visiting physicians are welcomed at all the reputable surgical centers employing hypothermia in this country. It is inexcusable that procedures using hypothermia with human beings should be attempted when the personnel involved have neither had prior experience with animals nor made clinical observations. Such eagerness to climb on the bandwagon of a spectacular method must certainly be condemned.

It is believed today that: (1) hypothermia can be a useful tool for diminution of metabolism under the proper circumstances and therefore has extended the frontiers of the field of surgery; (2) only a fraction of the physiologic variations involved during hypothermia have been thus far elucidated; and (3) one should embark into the field of clinical hypothermia only after obtaining some familiarity with the technique and after taking all precautions possible for the safety of the patients.



FIGS. 1 to 9.

Ending the Continuous Suture.—J. A. Carr.

THE SURGEON AT WORK

ENDING THE CONTINUOUS SUTURE

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THE CONTINUOUS SUTURE LINE must be ended by a knot, and the knot usually chosen is a reef knot in which one strand is tied against two. In fine material with a good "bite," such as thread, this knot may fulfill all requirements. However, when it is used on thickish catgut it produces a bulky knot, the three short ends obtrude, and such is the tendency to work loose that a third throw is often added, further increasing the bulk of the knot without adding much to its security.

A fixed bowline would appear to be a better knot to use, but difficulty arises in tying it under tension at the end of a suture line. This difficulty has been overcome, and the purpose of this article is to present the method used. In general terms the knot is completely formed in a loose state and then tightened in stages. The resulting knot is compact, firm, and has only one short end.

The illustration (Figs. 1 to 9) shows: (1) A suture line is sewed from left to right by a right handed operator. (2) A loop at the end of the cord is taken in the needle holder, and the main loop is displayed over the fingers of the left hand. (3) The point of the needle holder is made to follow the course of the arrow, and (4) as a result the cord becomes wound around the needle holder. (5) Care is taken that the end of the cord passes *under* the main loop, and the grip of the left thumb and finger is changed to near the end of the cord. (6) The grip of the needle holder is then transferred to the end of the cord, after passing *over* the main loop. (7) All the slack is now taken up between the loop around the needle holder and that around the left index. (8) The end of the cord is now withdrawn through the loop which was around the needle holder, and all the slack taken up in the loop around the left index. It is important that, in the last two manipulations, the loops should be drawn really tight. (9) Finally, the knot is completed by pulling on the end still held in the needle holder.

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PROBLEM OF INTRAHEPATIC STONES AND SUGGESTED SOLUTION

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THE HIGH INCIDENCE of retained common bile duct stones is the result not only of stones being missed at surgery but also of high intrahepatic stones descending after surgery to the lower reaches of the common duct. This factor attains significance in view of the fact that previous studies have demonstrated that approximately 8 per cent of the patients with cholelithiasis have intrahepatic stones. According to Best high intrahepatic stones may be "entirely unattainable by present day techniques."

At present, the common methods of coping with the problem of stones missed at surgery are: the Best regime, topical anesthetics instilled into the common duct, the use of various volatile solvents such as ether and chloroform, or forceful irrigation and flushing. These methods, while successful at times, have only partially solved the problem. Obstruction has occurred with the commonly used Kehr T tube as a result of stones which have actually passed through its horizontal limbs into the distal end of the common duct. Occasionally, a stone will inadvertently drain to the outside through the Kehr T tube.

A method will be described of the deliberate attempt to retrieve intrahepatic stones as they descend by diverting them to the outside of the body at the same time that the bile is permitted

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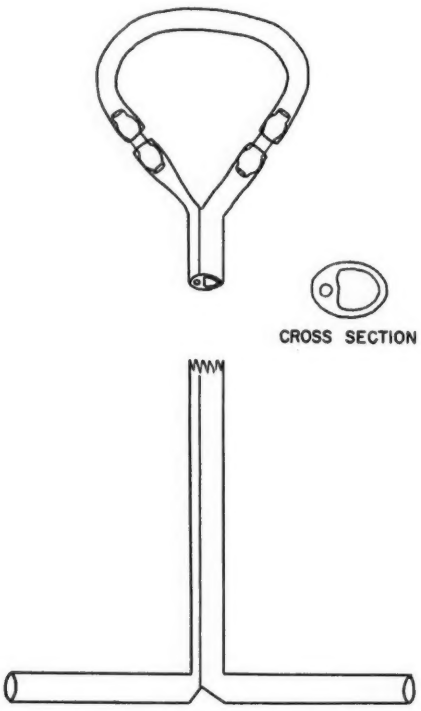

FIG. 1.

FIG. 1. New modified T tube in detail.
FIG. 2. New modified T tube in position in common bile duct. Note how intrahepatic stones are diverted to outside of body.

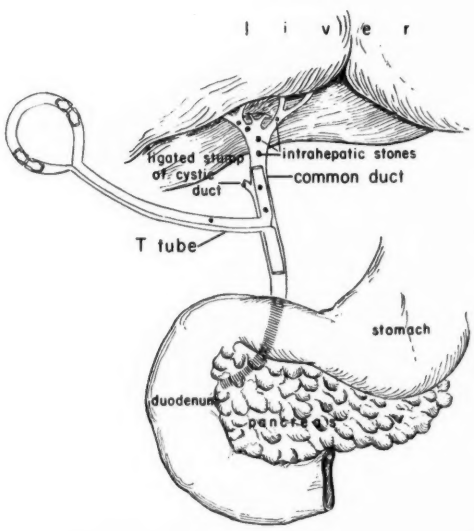

FIG. 2.

to flow into the distal end of the common bile duct.

To accomplish this purpose, a new tube (Fig. 1) has been devised which is designed to divert most of the bile to the outside of the body in order to filter it of debris and stones and then to return the filtered bile to the common bile duct. This tube also permits complete control of drainage and suction of either end of the common bile duct and of direct instillation of fluids toward either end. Irrigation of the Kehr T tube causes fluid to flow in both directions indiscriminately; suction is also dissipated in both directions. The new tube overcomes both of these objections.

DESCRIPTION OF NEW TUBE

The new tube is a double L tube which consists of 2 soft plastic or rubber L-shaped tubes,

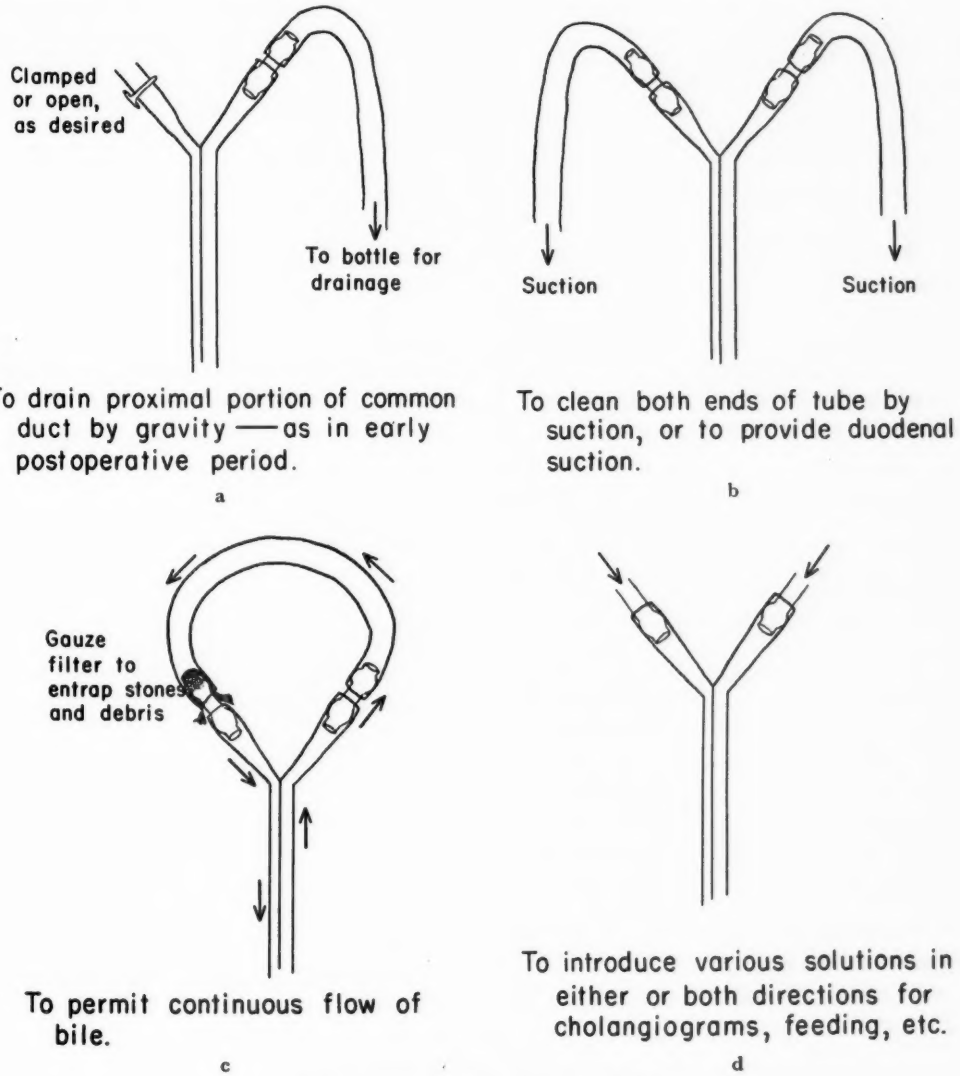
Clamped or open, as desired
To bottle for drainage
To drain proximal portion of common duct by gravity — as in early postoperative period.
a
Suction
Suction
To clean both ends of tube by suction, or to provide duodenal suction.
b
Gauze filter to entrap stones and debris
To permit continuous flow of bile.
c
To introduce various solutions in either or both directions for cholangiograms, feeding, etc.
d

FIG. 3. Various methods of using new T tube.

the long vertical arms of which are fused back to back. The proximal horizontal limb is sized to fit the lumen of the common bile duct snugly, thereby making it possible to entrap most of the bile flow and any contained stones. The vertical limb of this portion is of the same size. The distal horizontal limb is also of the same size, but the vertical component of the latter is much smaller (about size 8 French) to avoid leaving a larger hole in the common bile duct after removal of the tube. Since the total amount of fluid ever passed through the distal horizontal limb could be adequately carried by this smaller tube, there should be no objection to the smaller diameter. Indeed, the smaller tube would prevent any large stones from passing into the distal end of the common bile duct inadvertently when the connecting tube (Fig. 1) is attached. In actual practice, a gauze or metal filter may be interposed between the two limbs for the same purpose (Fig. 3c). The distal horizontal limb may be cut short, like the conventional tube, or left long. In the latter case, it may, if so desired, be inserted in an intraduodenal position like the Cattell tube.

The proximal ends of both vertical limbs are arranged with a connecting tube to permit easy detachment or attachment to each other (Fig. 3). The horizontal limbs are inserted into the common bile duct after surgical exploration, and the two fused vertical limbs are brought to the outside of the body through a stab wound, or through the lateral end of the transverse incision in the routine fashion. The proximal outside limb may be connected to a drainage bottle (Fig. 3a). The smaller outside distal limb may be temporarily clamped off until needed. If desired, the filtered bile can later be returned to the patient through the distal limb (Fig. 3d). The maximum effect can be obtained when used in conjunction with the Best regime.

OTHER ADVANTAGES OF THE NEW TUBE

Controlled irrigation and suction. The new tube permits independent irrigation or undissipated suction of either end of the common duct (Fig. 3b).

For cholangiograms. It permits more accurate cholangiograms since the dye may be injected in the desired direction (Fig. 3d). Following cholangiography, the dye may be removed almost in its entirety by suction, thus obviating the dangers ascribed to residual dye by Sherman and associates.

Safer instillation of solvents. Volatile solvents may be injected into the distal end only and not throughout the entire intrahepatic ductal system. On evaporation, the resultant gases may escape and thereby reduce the discomfort and possible toxicity commonly seen with these agents.

Instillation of local anesthetics. In like manner, local anesthetics such as pontocaine, to relax spasm of the sphincter of Oddi, may be deposited in their entire concentration exactly where needed, and not uselessly dissipated upward into the liver radicles.

Direct alimentation. By using the distal limb, total alimentation by dripping various solutions directly into the duodenum is possible. Thus saline, glucose solutions, electrolytes, and even protein hydrolysate mixtures may be administered without risking the danger of chemical irritation of the liver and cholangitis.

Possible decompression of duodenum. Use of the distal limb of the tube as a means of decompressing the duodenum and small intestine is a theoretic possibility (Fig. 3b).

Visible flow of bile. When patency of the common bile duct has been established, the outside limbs are joined by a transparent connecting tube, and the free flow of bile through it may be readily observed.

SUMMARY

Many "missed" common bile duct stones are in reality of intrahepatic location and cannot be recovered at the time of surgery, but they descend into the common duct after surgery.

A new tube is described and recommended as an aid in retrieving these stones before they descend into the narrow distal end of the common duct.

The tube also offers a more controlled method of treatment for stones actually missed at surgery.

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AIDS IN THE DIAGNOSIS OF SUBPHRENIC AND OTHER INTRA-ABDOMINAL ABSCESSES

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THE USE OF ANTIBIOTICS has so reduced the incidence of postoperative intra-abdominal infection that we are inclined to forget about it. Furthermore, the employment of a wide range of antibiotics tends to mask infection when present and to delay the recognition of abscess. This is particularly true in the deeper areas of the abdomen, notably the subphrenic and subhepatic spaces, in the omental bursa, and in the pelvis.

In the first instance, the old dictum of Dennis is still worth keeping in mind: "Pus somewhere, pus nowhere = pus under the diaphragm." In a given patient with fever, leucocytosis, and malaise, yet no localized tenderness, the surgeon fears to aspirate the subphrenic space and turns to the roentgenologist for help, to ascertain whether there is fluid in the costophrenic angle, and whether the diaphragm is fixed or moves with respiration. By this time the patient often cannot take a good deep breath, and the roentgenologist is unable to say whether there is diaphragmatic fixation or whether the patient is just too ill to stand upright behind a fluoroscope and breathe deeply.

We have employed a useful method to solve this question. With the patient either standing or lying on the fluoroscopic table, a saline-moistened electrode, such as used for muscle stimulation, is placed over the easily palpable scalenus anticus muscle in the neck and a mild faradic shock is given (Fig. 1). This stimulus to the phrenic nerve through the skin is quite effective in evoking contracture of the diaphragmatic musculature. The shock is not painful to the patient. In a normal patient, the diaphragm on the stimulated side immediately makes a forceful descent of from 3 to 5 inches. Under the conditions of suspected sepsis mentioned, absence of contraction usually means fixation by inflammation above or below the diaphragm. In other words, the nerve impulse is supplied which a sick and perhaps distended patient cannot furnish himself. Such electrophrenic stimulation in poliomyelitis with respiratory paralysis has been practiced by Macaulay without harm for several years.

We have also found the method of suction tip reconnaissance and drainage, inconspicuously described by Wangensteen to be of increasing value. Using local anesthesia, the operator plans 4 short abdominal incisions: a right and a left upper abdominal incision just opposite the end of the tenth rib, and a right and a left lower abdominal incision of the McBurney type. Using the long suction tip of the type here described, the operator gently explores the most suspicious area; if pus, bile, or serous or hemorrhagic collections are found, open drainage is instituted; if not, the other areas are successively explored. By this procedure, one can reach the right and left subphrenic spaces, the subhepatic area, both paracolic gutters, and collections in the true pelvis. On one occasion following a perforated posterior gastric ulcer, it was possible to find and drain a purulent collection within the omental bursa, although this is admittedly a re-

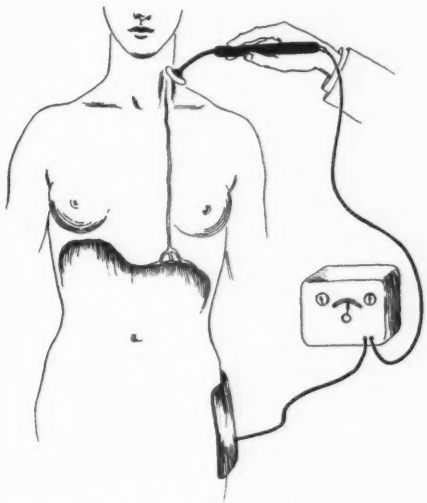

FIG. 1. Method of testing diaphragmatic movement under the fluoroscope.

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mote area to reach by suction tip reconnaissance. This method is of decided value when leakage from a duodenal stump is suspected.

At first, we were concerned lest the suction tip perforate a segment of intestine and give rise to fistula formation. This has not occurred. The secret seems to be in keeping the suction tip *close against the parietal peritoneum*, rather than forcing it medially. In exploring the subhepatic space, the tip is kept close against the under surface of the liver which acts as a safe guide.

As Wangensteen has observed: "The method departs from the teaching of convention on this score, in that the abscess is not opened *extraserously*. I regard it as far more important however, to *find* the abscess," rather than to let the patient die.

The suction tip illustrated (Fig. 2) differs somewhat from other models: The tip is semiflexible, and it is quite long, allowing access to the depths of the pelvis and to the very top of the liver (on one occasion, it was possible to locate thus and drain, a high liver abscess). The glass collecting bottle allows immediate recognition of the character of fluid being encountered at any time or position (blind suction tips do not permit this), and provides a specimen for culture.

FIG. 2. Long flexible suction tip for abdominal reconnaissance.

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THE SURGEON'S LIBRARY

Reviews of New Books

THE EXCELLENT HANDBOOK *The Diagnosis and Management of Urological Cases*[1] is for the intern, the resident, and the general practitioner. To those new at handling urologic cases, this book should be a real help. The authors have made this text practical and to the point. They have left out pathology and operative technique, and rightly so.

Also, the authors have produced a work that is enjoyable to read. No hard or difficult paragraphs to decipher are encountered in any place. Each subject is described with clarity, and positive statements leave little doubt of their meaning.

The diagrams are clear, and what explanation is necessary is never difficult to follow.

All the chapters are interesting. However, the first chapter, on means of examining a patient for urologic disease, is outstanding.

The chapter dealing with genitourinary tuberculosis is also very good. The authors speak their parts fearlessly. They leave no doubt that such an infection is bilateral in type from the onset and urge bilateral catheterization of ureters to make a diagnosis if this becomes necessary.

For those for whom this book is intended, I am sure it will be a real boon. —*Thomas L. Pool.*

THE VOLUME entitled *Surgical Diagnosis*[2] is essentially a text in correlative physical diagnosis covering lesions of surgical significance. A consistent effort is made to present the reader with the salient and simplified symptomatology of the more common pathologic entities along with the artist's diagrammatic version of the pathology and physical findings. The result is a lucid, clearcut, somewhat dogmatic presentation which has good teaching value. The art work is of excellent quality and impressively voluminous, there being 291 figures among 293 pages of text. It is printed on paper of fine quality.

The scope of the book is wide, the emphasis being on the neck, chest, breast, and abdomen. Minimal but sufficient coverage is given to the genitourinary and gynecologic problems that might enter into the differential diagnosis of anatomically related general surgical pathology. The section on abdominal injuries is a pertinent addition in our times of high speed, but the last 2 chapters obviously are incomplete, with respect to scope and content. For example, the last chapter includes only 4 pages limited to descriptions and pertinent diagrams of saphenous varicosities. The author makes the common error of giving minimal consideration to the lesser saphenous vein as a source of significant venous reflux in the production of varicosities. An incidence as high as 15 per cent has been reported by others in this regard.

In the section on the breast the term *mastodynia* is applied to one of three types of breast dysplasia, whereas in reality this word denotes nothing more than a symptom. This is more than a matter of semantics. The classification of hyperplasia, cystic disease, and sclerosing adenosis would fit the author's needs much better in this regard. With reference to mastitis in the male, one finds it difficult to relate this condition to the trauma of suspenders. Further on, in the section on the spleen, the term "flat roentgenogram" is used. The term "scout film of the abdomen" would be better usage for all roentgenograms are essentially flat or level.

This text can be recommended highly for medical students, residents, and nurses having advanced training. It is easy to read, and its liberal use of visual aids is commendable. This text is designed to stimulate the physician to utilize the patient's history and his own physical findings in order to arrive at a working diagnosis without recourse to laboratory data. Undoubtedly, the reader will wish to dig deeper into one or another selected subject. He receives no help from the author in the form of bibliography or references, and for this omission, the book can be criticized. References could easily be added at the end of each chapter without any alteration of the typesetting, since there is adequate space for this as the book now stands. —*Walter W. Carroll.*

THE THIRD VOLUME of the new second edition of König and Magnus' well known work on the treatment of accidental injuries,[3] edited by Professor H.

[1] THE DIAGNOSIS AND MANAGEMENT OF UROLOGICAL CASES. A HANDBOOK FOR STUDENTS, RESIDENTS AND GENERAL PRACTITIONERS. By Bruce W. T. Pender, M.B., B.S., F.R.C.S., and James O. Robinson, M.A.(Cantab.), M.Chir., F.R.C.S. 170 pages, 48 illustrations. $5.00. Baltimore: The Williams &Wilkins Co.; London: Baillière, Tindall & Cox, 1955.

[2] SURGICAL DIAGNOSIS. By Philip Thorek, M.D., F.A.C.S., F.I.C.S. With drawings by Carl T. Linden, 320 pages, 291 illustrations. $12.00. Philadelphia and Montreal: J. B. Lippincott Co., 1956.

[3] HANDBUCH DER GESAMTEN UNFALLHEILKUNDE. Edited by Prof. Dr. H. Bürkle de la Camp and Prof. Dr. P. Rostock. 2nd rev. ed., Vol. III of a three volume set. 701 pages, 134 illustrations. DM 105.—Stuttgart: Ferdinand Enke Verlag, 1956.

Bürkle de la Camp and Professor P. Rostock, is divided into 4 sections. Section 6, the first in this volume, and entitled "Injuries of the Extremities," comprises a little more than one-half of the 700 pages. In it are included "Injuries of the Upper Extremity" (Prof. B. Karitzky), and "Injuries of the Pelvis and Lower Extremities" (Prof. H. Bürkle de la Camp, Dr. W. Arens, Dr. A. Balthasar, Dr. W. Beck, and Dr. F. Betzel). In Section 7 are included "Aftercare and Prostheses" (Prof. M. Hackenbrock and Prof. O. Hepp); in Section 8 "Industrial Diseases" (Prof. J. Hager); and in a brief concluding section (Prof. P. Rostock) a table expressing in percentages loss of function resulting from injuries of various portions of the body.

The 144 page chapter 21 on injuries of the upper extremities is devoted almost entirely to injuries of the bones and joints. For the most part, the author recommends methods of treatment that would be universally accepted. In the treatment of recurrent dislocation at the shoulder joint he advocates building up the glenoid margin with a free intra-articular bone transplant (Eden, Hybínette), or with an extra-articular transplant in a periosteal pocket derived from the neck of the scapula (von Fessler, Magnus, Ahrens). He deprecates plastic procedures which involve the use of muscle, tendon, and fascia, and does not mention the Nicola operation.

Aside from the excellent descriptions of injuries of the soft tissues complicating bone and joint injuries only 20 pages are devoted to tendon injuries, and 5 to infections. A brief note at the end of the section states that lack of space and the desire to emphasize well established methods have made it necessary to omit reference to the work of many contributors to the surgery of the upper extremities. This seems unfortunate, particularly in view of the fact that, in the author's words, the cost of compensation following injuries of the hand is greater than that following all the fractures of all the long bones.

In view of the widespread interest that has developed in England, France, the Scandinavian countries, and America in the subject of hand injuries, one would be happy to see that development reflected more fully in this well known work for the benefit of German surgeons and students.

Chapter 22 of 246 pages, devoted to injuries of the pelvis and lower extremities, includes a section of 53 pages on the pelvis, of 50 pages on the hip joint and upper end of the femur, of 20 pages on the shaft and trochanters, of 38 pages on the knee joint, and of 86 pages on the lower leg and foot. In each section, in addition to discussion of bone and joint injuries, the authors have devoted considerable space to a consideration of injuries of the soft parts associated with fractures and displacements; for example, with fractures of the pelvis a comprehensive comment upon bladder and urethral injuries (occurring in 10 per cent of 879 patients with fractures of the pelvis); with injuries of the lumbar spine-preperitoneal and retroperitoneal hematoma, other blood vessel injuries, nerve, and ligamentous injuries. They have included also discussions of clinical entities—Legg-Calvé—Perthes disease, coxa vara and valga, congenital dislocation of the hip, osteochondritis of hip and knee joint, osteomyelitis, acute and chronic, and the many clinical entities affecting the lower extremity which are usually grouped under "Orthopedic Surgery." In fact, this chapter constitutes an admirable presentation of the "Orthopedic Surgery" of the pelvis and lower extremity, with recurring emphasis upon the results of injury from the standpoint of possibility of recovery and of cost of compensation for the injured individual.

Two well written chapters on "After-treatment Following Injuries" and "Orthopedic Aids and Artificial Limbs," the latter illustrated with a number of helpful diagrams and photographs, present an excellent review of these subjects.

The concluding major section, Section 8, entitled "The Indemnifiable Occupational Diseases," is a veritable encyclopedia of the many localized and general diseases and injuries which can arise from contact with or the use of various inorganic and organic chemicals, from the use of mechanical devices (such as compression tools), from radiation, from infection, and parasites.

Under 40 different headings beginning with diseases resulting from poisoning with lead and its compounds, through diseases resulting from exposure to roentgen rays and radioactive substances, diseases resulting from working with tools driven by compressed air or working in air pressure chambers, to diseases of the teeth from organic acids, diseases of the cornea from benzochinon, and diseases transmitted from animals to man, the author has compressed a tremendous amount of information which can well serve as an exceedingly helpful reference work for every worker concerned with the problem of industrial disease and injury.

—*Sumner L. Koch.*

THE MONOGRAPH entitled *Atlas der Kolpomikroskopie*,[4] from the University Frauenklinik in Vienna, consists of 244 pages and 181 illustrations, 2 of which are in color. In the first several pages the colpomicroscope and its incident light source are demonstrated, its development as an advancement from the colposcope of Hinselmann is described, and the technique of its use is discussed. The paragraphs devoted to technique are translated into English. The major portion of the book presents excellent reproductions of the colpomicroscopic view of the cervix with magnifications up to 280 times. Normal and abnormal epithelia are shown and in each instance histologic sections from corresponding areas are reproduced for comparison. The legends for each illustration are in German, English, and Spanish.

The stated purpose of the volume is to teach the interpretation of colpomicroscopic views by means of illustrations and thereby to remove an obstacle to more widespread use of the colpomicroscope. The authors believe that the instrument is a necessary tool in the gynecologist's armamentarium for detection of early cancer in the cervix. It is stated that the instrument does not establish whether or not invasion is present. A peculiar and distinct advantage in the use of the instrument is the opportunity for micro-

[4] ATLAS DER KOLPOMIKROSKOPIE. By Prof. Dr. Tassilo Antoine and Doz. Dr. Viktor Grunberger. 224 pages, 176 illustrations. Stuttgart: Georg Thieme Verlag, 1956.

scopic examination of *in situ* living tissue, with its variations over a period of time becoming apparent to repeated studies without the introduction of artefactual trauma.

The illustrations readily distinguish normal from abnormal tissue, indicating that the colpomicroscope is of definite value in the study of changed cervical epithelium and that the atlas should be very useful as an aid to correct interpretation. —*John I. Brewer.*

THE COLLECTION of 14 original articles in the volume *Studies on Fertility*[5] includes papers read at the Conference of the Society for the Study of Fertility at Birmingham in 1955, and represents the seventh annual volume of the proceedings of the Society.

Seven of the articles are concerned with fertility in the male, of which 2 deal with human fertility and 5 with fertility in the experimental animal. Seven of the articles are concerned with fertility in the female, of which 3 are concerned with human fertility and 4 with fertility in the experimental animal. The papers are of high scientific quality and well worth reading.

Of special interest is one report of 2 cases of idiopathic retrograde ejaculation. Cervical insemination of the bladder ejaculate was performed successfully on 2 occasions for one couple who now have 2 healthy boys as a result. —*Frederick A. Lloyd.*

AS STATED IN THE INTRODUCTION, the book entitled *Modern Trends in Orthopedics*[6] is not to be considered as a textbook of orthopedic surgery. It is a collection of excellent essays on various subjects of interest to orthopedic surgeons and it is not arranged as a progressive text nor does it start with fundamentals and build up to advanced work. It is assumed that the reader has knowledge of the essential elementary foundations of the subjects covered. Among the topics discussed in the book are peripheral nerve injuries, reconstructive hip surgery, traumatic paraplegia and Pott's paraplegia, congenital dislocation of the hip, some phases of hand surgery, and various types of coxa vara. There is a very complete essay on internal derangements of the knee by J. Grant Bonnin, a fine chapter on fractures of the neck of the femur by C. H. Gray, and a fine consideration of the role of antibiotics in the treatment of skeletal tuberculosis.

Each chapter is written by a surgeon who has had extensive experience with his subject. In all chapters the presentations are portrayed smoothly and in many instances they are embellished with interesting historical background. Statistical analyses of series of cases seem to be given with clarity and honesty. This is particularly true in the comprehensive chapter on congenital dislocation of the hip by Sir Harry Platt and in the chapter on Pott's paraplegia written by H. J. Seddon. Certainly both Platt and Seddon have contributed worthily to the volume.

The subject of peripheral nerve injuries is very well handled by Roland Barnes. His treatment of the material is thorough, well organized, and objectively presented. All the essayists have the unique facility of presenting their ideas vividly from a wealth of clinical experience.

The illustrations include both diagrams and photographs and are quite adequate. A few errors in proof reading exist but they are not confusing and are of minor importance.

The book is highly recommended for orthopedic surgeons who should find in its pages valuable suggestions and instructive experiences.

—*Harold A. Sofield.*

FOLLOWING THE MODERN TEMPO and somewhat in the style of a news magazine, Bettmann[7] has produced a pictorial survey of medical history from the time of the early Egyptians to the beginning of the twentieth century. One sees clearly depicted on these pages the struggle between medical practice based upon study and observation of the patient on one hand, and medicine based upon theory or faith, on the other. Since the story stops with the end of the nineteenth century one gets only a glimpse of those scientific discoveries which marked the beginning of modern medicine. It seems logical to stop there since today the contest is not between theory or faith and study of the patient, but between study of the patient and reliance upon laboratory data for guides to diagnosis and treatment. Perhaps nowhere else can one obtain so clearly and quickly a broad grasp of medical history. The hundreds of illustrations depict in their well chosen selection the highlights in medical practice through the centuries. We have here the essence of the artists' concepts of the physician, some favorable some unfavorable, but all honest and authentic records. This is not, however, simply a picture book, but a series of brief historical essays dealing with those events and conditions of practice which characterize periods of medical development.

Starting with Egyptian medicine, of which some excellent records obtain, there then follow chapters on Greek and Roman medicine. A chapter on the early middle ages is followed by one on Moslem medicine recounts the decline of European practice after the death of Galen and the reintroduction of Greek medicine by the Moslems. The late middle ages, which saw the establishment of Salerno and other schools throughout Europe finally bogged down in the mire of scholasticism and theology. The chapter on the Renaissance outlines the struggle against authority, spearheaded by artists in their study of anatomy. This, the age of Paracelsus, Paré, and Vesalius, to name only a few, saw the break with tradition and the beginning of scientific medicine. The seventeenth century saw the doctor return to the bedside. The chapter on the eighteenth century depicts the great rise of English and Scottish medicine, the Monros, Hunter, Jenner, and the establishment of medical schools in America. Two chapters are devoted to the nineteenth century, the first half of which among

[5]STUDIES ON FERTILITY. Edited by R. G. Harrison, M.A., D.M. Vol. VII of the Proceedings of the Conference of the Society for the Study of Fertility. 156 pages, illustrated. $5.00. Springfield, Ill.: Charles C Thomas; Oxford: Blackwell Scientific Publications, 1955.

[6]MODERN TRENDS IN ORTHOPEDICS. (Second Series). Edited by Sir Harry Platt, LL.D., M.D., M.S., F.R.C.S., F.A.C.S. 331 pages, 226 illustrations. $12.50. New York: Paul B. Hoeber, Inc., Medical Book Department of Harper & Bros., 1956.

[7]A PICTORIAL HISTORY OF MEDICINE. By Otto L. Bettmann, Ph.D. With a foreword by Philip S. Hench, M.D. 318 pages, illustrated. $9.50. Springfield, Ill.: Charles C Thomas, 1956.

other things saw the development of ether anesthesia, and the beginning of specialization. The second half records the great upsurge of German medicine, and the experimental methods. Koch, Lister, Pasteur and Roentgen, Osler, Welch, Walter Reed, and many others, too numerous to list, usher in the twentieth century.

Altogether this book is an attractive and quite readable account of the growth of our profession. One wishes that more information could have been furnished as to sources of the illustrations. A liberal bibliography is given, although as the author says, a complete list of references would fill a volume.

—*Michael L. Mason.*

BOOKS RECEIVED

Books received are acknowledged in this department, and such acknowledgment must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interests of our readers and as space permits.

VIGESIMOSEXTO CONGRESO ARGENTINO DE CIRUGIA. Presidente: Dr. Alejandro J. Pavloysky. Fasciculo II: sesion inaugural. Published under the direction of Dr. J. Alfredo Ferreira. Buenos Aires: En la Secretaria de la Asociacion, 1955.

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PRACTICAL OFFICE GYNECOLOGY. By Albert Decker, M.D., D.O.G., F.A.C.S., and Wayne H. Decker, M.D., D.O.G. 338 pages, 103 illustrations, 19 in color. $10.50. Philadelphia: F. A. Davis Co., 1956.

PREGNANCY AND BIRTH; A BOOK FOR EXPECTANT PARENTS. By Alan Frank Guttmacher, M.D. 335 pages, illustrated. $4.50. New York: The Viking Press, Inc., 1957.

THE RECURRENT LARYNGEAL NERVES IN THYROID SURGERY. By William H. Rustad, M.D. 47 pages, illustrated. $4.50. Springfield: Charles C Thomas, Publisher, 1956.

THE ROCKEFELLER FOUNDATION ANNUAL REPORT, 1955. By The Rockefeller Foundation. 350 pages, illustrated. New York: The Rockefeller Foundation, 1956.

PRACTICAL DIAGNOSIS AND TREATMENT OF LIVER DISEASE. By Carroll Moton Leevy, M.D. Foreword by Franklin M. Hanger, M.D. 336 pages, 50 illustrations. $8.50. New York: Paul B. Hoeber, Inc., 1957.

SURGERY IN WORLD WAR II. ORTHOPEDIC SURGERY IN THE EUROPEAN THEATER OF OPERATIONS. Edited by Col. John Boyd Coates, Jr., MC, Mather Cleveland, M.D., and Elizabeth M. McFetridge, M.A. 397 pages, 87 illustrations. Washington, D.C.: Office of the Surgeon General, Department of the Army, 1956.

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THE GIST OF OBSTETRICS. By H. B. Atlee, M.D. Illustrated by Garth Vaughan, M.D. 327 pages, 88 illustrations. $6.00. Springfield, Ill.: Charles C Thomas, Publisher, 1957.

CONNECTIVE TISSUE IN HEALTH AND DISEASE. Edited by G. Asboe-Hansen, M.D. 321 pages, illustrated. $15.00. Copenhagen: Ejnar Munksgaard; New York: Philosophical Library, 1957.

PEDIATRIC CARDIOLOGY. By Alexander S. Nadas, M.D., F.A.A.P. 587 pages, 343 illustrations. $12.00. Philadelphia and London: W. B. Saunders Co., 1957.

THE PHYSICIAN-WRITER'S BOOK; TRICKS OF THE TRADE OF MEDICAL WRITING. By Richard M. Hewitt, A.M., M.D. 415 pages, 37 illustrations. $9.00. Philadelphia and London: W. B. Saunders Co., 1957.

CLINICAL USE OF RADIOISOTOPES. By William H. Beierwaltes, M.D., Philip C. Johnson, M.D., and Arthur J. Solari, B.S., M.S.(Physics). 456 pages, 126 illustrations. $11.50. Philadelphia and London: W. B. Saunders Co., 1957.

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DIE GESUNDE UND DIE KRANKE WIRBELSAULE IN ROENTGENBILD UND KLINIK; PATHOLOGISCH-ANATOMISCHE UNTERSUCHUNGEN. By G. Schmorl. FUER ROENTGENKUNDE UND KLINIK. By H. Junghanns. 332 pages, 419 illustrations. $20.50. Stuttgart: Georg Thieme Verlag, 1957.

THE PRINCIPLES AND ART OF PLASTIC SURGERY. By Sir Harold Gillies, C.B.E., F.R.C.S., and D. Ralph Millard, Jr., M.D. Chapter on Anaesthesia by Ivan Magill, C.V.O., F.F.A.R.C.S. With a foreword by Jerome Pierce Webster, M.D. Vols. I and II. 662 pages, illustrated. $35.00. Boston and Toronto: Little, Brown & Co., 1957.

STRESS AND STRAIN IN BONES; THEIR RELATION TO FRACTURES AND OSTEOGENESIS. By F. Gaynor Evans, Ph.D. 245 pages, 42 illustrations. $6.50. Springfield, Ill.: Charles C Thomas, Publisher, 1957.

ANTONIO SCARPA IN SCIENTIFIC HISTORY AND HIS ROLE IN THE FORTUNES OF THE UNIVERSITY OF PAVIA. By Prof. Achille Monti. Translation by Frank L. Loria, B.S., M.D., F.A.C.S. 125 pages, illustrated. $4.50. New York: The Vigo Press, 1957.

CHIRURGIE ORTHOPÉDIQUE DES PARALYSIES. By R. Merle D'Aubigné, J. Bénassy, and J. -O. Ramadier. In collaboration with 12. 432 pages, 171 illustrations. 5.000 fr. Paris: Masson et Cie, Editéurs, 1956.

ANATOMIE ET CHIRURGIE DU PÉRICARDE; APPLICATIONS A LA CHIRURGIE BRONCHO-PULMONAIRE. By Henri Milhiet and Paul Jager. Preface by J. Baumann. 292 pages, 145 illustrations. 4.000 fr. Paris: Masson et Cie, Editéurs, 1956.

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1. Knoch, H.R., and Kirk, R.: Proclorperazine—A New Agent for the Treatment of Psychic Stress, in manuscript.

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